

SEABIRD 19



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S. Wanless

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Frequency of mixed clutches in seabird colonies

J.C.A. Craik

INTRODUCTION

In seabird colonies, nests are occasionally found that contain the eggs of more than one species. Although the phenomenon is well known (Campbell & Lack 1985), the frequency with which it occurs appears not to have been measured. This report, based on findings in west Scotland over a six-year period, records the seabird species whose eggs were found in mixed clutches and the proportion of clutches affected.

Of all such nests found in this work, none recognisably contained the eggs of more than two species. Clutches containing the eggs of two species are described here as "mixed clutches".

METHODS

This work was carried out along the mainland coast of west Scotland, between the towns of Mallaig and Machrihanish, during the years 1990-1995. Clutches were observed of the following species: Shag *Phalacrocorax aristotelis*, Eider *Somateria mollissima*, Red-breasted Merganser *Mergus serrator*, Oystercatcher *Haematopus ostralegus*, Black-headed Gull *Larus ridibundus*, Common Gull *Larus canus*, Herring Gull *L. argentatus*, Great Black-backed Gull *L. marinus*, Common Tern *Sterna hirundo* and Arctic Tern *S. paradisaea*.

One hundred and twenty sites held nests of one or more of these species; eight of these sites were on mainland shore (two roofs, one freshwater lochside, five sealoch sides; all eight were Common Gull colonies). The other 112 sites were marine islands within five km of the mainland coast (members of island pairs, or of island groups, separated by sea at the lowest tides are each treated as single islands in this total). Most sites were used annually by breeding seabirds. Most colonies held more than one species and it was not unusual to find five or six of the study species breeding on a single small island of 20 x 70 m.

During routine nest and clutch counts each year, a record was made of the numbers of eggs and the species involved in each mixed clutch that was observed. A simultaneous count was kept of the numbers of normal (single-species) clutches that were seen. Empty nests and broods were not included in the latter count, which at some colonies was considerably less than the numbers actually breeding.

RESULTS

Frequency and composition of mixed clutches

During the six-year period, 26,305 normal clutches and forty mixed clutches were seen; thus the overall frequency was 0.15%. The numbers in each of these years are given in Table I. The annual frequencies varied between 0.025% in 1993 and 0.24% in 1995. The reason for the unusually low frequency in 1993, when only one mixed clutch was recorded, is unknown.

Eggs were warm in most of the mixed clutches. None had the chalky, wet, dirty, displaced or otherwise abandoned appearance of deserted eggs.

The sizes and compositions of the forty mixed clutches are given in the Appendix.

Species most frequently found in mixed clutches

The species most frequently found in mixed clutches were Common Gull, Oystercatcher, Eider, Black-headed Gull and Herring Gull, in that order (Table II). These five species together accounted for 68 of the 80 half-pairs involved in mixed clutches (85%). This order of species was markedly different from that of the numbers of clutches examined (also Table II).

A chi-squared test applied to the data of Table II, combining the bottom four species into one category, gave $\chi^2 = 346$ (df = 6, $P < 0.001$). This suggests that some species were more likely to occur in mixed clutches than others. Inspection of Table II shows that Oystercatcher, Eider and Merganser, in particular, were found in mixed clutches at disproportionately high frequencies.

This may be because less numerous species (Eider) and solitary, non-colonial species (Oystercatcher, Merganser) were surrounded at these colonies by high densities of nests of species such as Common or Herring Gulls, rather than because of an inherently greater tendency

TABLE I. NUMBERS OF NORMAL AND MIXED CLUTCHES RECORDED 1990-1995

	1990	1991	1992	1993	1994	1995	Total
<i>A) Total numbers of clutches recorded</i>							
Shag	16	16	87	132	244	327	822
Eider	34	64	73	63	130	131	495
Red-breasted Merganser	1	4	1	0	2	4	12
Oystercatcher	14	39	52	41	53	56	255
Black-headed Gull	128	336	568	465	399	314	2210
Common Gull	630	924	973	777	1016	1021	5341
Herring Gull	530	987	438	656	2714	1723	7048
Great Black-backed Gull	15	38	34	58	176	135	456
Common Tern	1239	1390	1618	1389	1149	1068	7853
Arctic Tern	215	418	243	369	271	297	1813
Total	2822	4216	4087	3950	6154	5076	26,305
<i>B) Numbers of mixed clutches recorded</i>							
	4	5	7	1	11	12	40
Mixed as percent of total	0.14	0.12	0.17	0.03	0.18	0.24	0.15

TABLE II. FREQUENCY OF EACH SPECIES IN MIXED CLUTCHES 1990-1995

<i>Species</i>	<i>Number of occurrences as half-pair</i>	<i>Number of clutches recorded</i>	<i>Percent</i>
Common Gull	21	5341	0.39
Oystercatcher	15	255	5.9
Eider	11	495	2.2
Black-headed Gull	11	2210	0.5
Herring Gull	10	7048	0.14
Common Tern	6	7853	0.08
Arctic Tern	2	1813	0.11
Great Black-backed Gull	2	456	0.44
Shag	1	822	0.12
Red-breasted Merganser	1	12	8.3
Total	80	26,305	0.3

Note that overall percentage is twice that given earlier because each mixed clutch involves two species

of Eider, Merganser and Oystercatcher to participate in mixed clutches. Similarly, the low frequency of mixed clutches in Common Tern (Table II) was probably because most large colonies of this species were almost monospecific and remote from colonies of other species. Local opportunity must play a large part in determining mixed clutch frequency within a species.

Species-pairs most frequently found in mixed clutches

The most frequent combinations of species were Common Gull-Oystercatcher (8/40), Common Gull-Black-headed Gull (7/40) and Herring Gull-Eider (6/40), these three together accounting for over half of the forty mixed clutches recorded. There were eight least-frequent combinations, each with only a single mixed clutch (Table III).

Inspection of Table III suggests that mixed clutches from species with similar-sized eggs (first three pairs in Table III, plus Eider-Merganser, Eider-Great Black-backed Gull, Herring Gull-Shag, which together accounted for 24/40 mixed clutches) were more frequent than those with a marked disparity of egg size, such as terns with larger-egged species (8/40). This was investigated quantitatively as follows.

Mean egg length L and width W for each of the ten species were obtained from Cramp (1977, 1983 and 1985). Ratio of egg volumes for each species-pair was calculated from LW^2 for the larger egg divided by LW^2 for the smaller egg. Ratios so obtained ranged from 1.07 for Common Gull-Oystercatcher and 1.08 for Great Black-backed Gull-Eider to 2.64 for Common Gull-Arctic Tern and 5.64 for Eider-Arctic Tern (Table III).

TABLE III. FREQUENCY OF SPECIES-PAIRS IN MIXED CLUTCHES 1990-1995

<i>Species-pair</i>	<i>No. of mixed clutches</i>	<i>Ratio of egg volumes</i>
Common Gull - Oystercatcher	8	1.069
Common Gull - Black-headed Gull	7	1.37
Herring Gull - Eider	6	1.291
Common Tern - Oystercatcher	3	2.315
Common Gull - Herring Gull	2	1.654
Common Gull - Eider	2	2.136
Black-headed Gull - Oystercatcher	2	1.28
Black-headed Gull - Common Tern	2	1.807
Common Gull - Arctic Tern	1	2.642
Common Gull - Common Tern	1	2.475
Herring Gull - Oystercatcher	1	1.768
Herring Gull - Shag	1	1.68
Great Black-backed Gull - Eider	1	1.078
Great Black-backed Gull - Oystercatcher	1	2.462
Eider - Red-breasted Merganser	1	1.582
Eider - Arctic Tern	1	5.64
Total	40	

Ratio of egg volume between two species in a pair was calculated as in following example.

Common Gull eggs have length 58 and width 41 mm $LW^2 = 97498$

Oystercatcher eggs are 57 x 40 mm $LW^2 = 91200$

Ratio (larger / smaller) = 1.069

See text for source of egg dimensions.

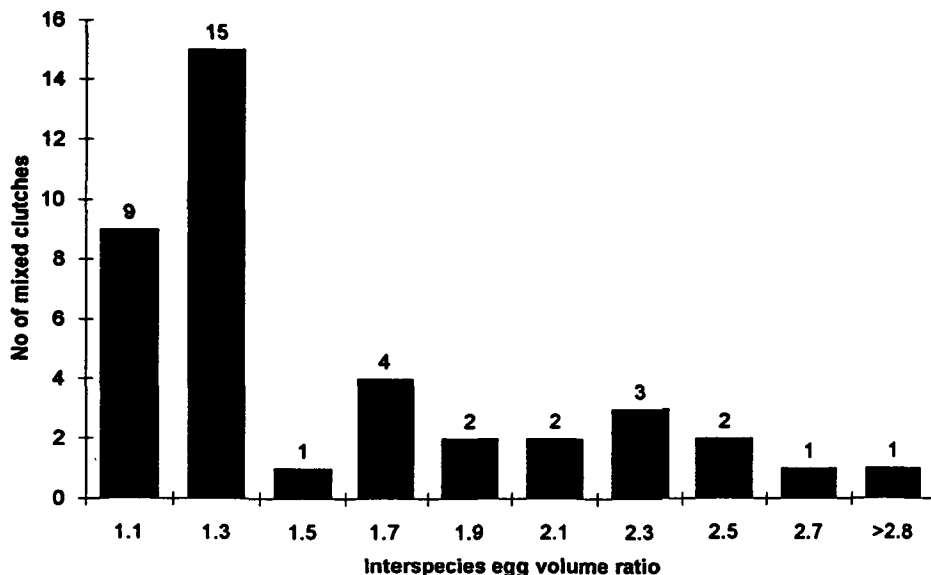


Figure 1. Histogram showing the numbers of mixed clutches in relation to the ratio of egg volumes of the two species involved (larger egg/smaller egg). 1.1 denotes ratios of 1.00-1.19:1, 1.3 denotes ratios of 1.20-1.39:1, etc. The diagram illustrates that, in the majority of mixed clutches, the two species involved had eggs of similar volume.

A histogram of the frequencies of this ratio in the mixed clutches is shown in Fig.1. A chi-squared test applied to the data of Fig.1 rejected the null hypothesis that mixed clutches were equally frequent with respect to egg volume ratio. (For this test, frequencies were combined within values of this ratio of 1.00-1.39, 1.40-1.79, etc. $\chi^2 = 41$, $df = 4$, $P < 0.001$). Inspection of Fig.1 shows that this is because mixed clutches were much more frequent when the ratio of egg volumes of the two species was closer to unity. It is concluded that mixed clutches are more likely to be formed by two species with eggs of similar size than by two species with eggs of very different size.

Frequency of mixed clutches in relation to island size

The islands were classified as small (less than 100 m in maximum length), medium (100-500 m), and large (more than 500 m). Of the 112 islands visited, 54 (48%) were small, 31 (28%) were medium and 27 (24%) large. Over the six years, mixed clutches were found at 24 (22 islands, 2 mainland) of the 120 sites visited. Of the 22 islands, fourteen were small, seven were medium and one was large. These two sets of frequencies did not differ significantly ($\chi^2 = 4.7$, $df = 2$, ns) indicating that occurrence of mixed clutches was not associated with island size.

Frequency of mixed clutches in relation to nest density

Nest densities were not measured quantitatively in this work. Instead, at each site the density of nests of the principal species present was classified as high or low for that species. This subjective assessment was made on the basis of fifteen years' experience of these species in this area.

Of the 24 sites at which mixed clutches were found, 16 were high-density and 8 were low-density, compared with a ratio of 46:74 for all 120 sites visited ($\chi^2 = 8.15$, $df = 1$, $P < 0.01$).

On this provisional basis, it was concluded that mixed clutches tended to occur more at colonies with higher densities of nests. However, this conclusion requires confirmation by quantitative rather than qualitative assessment of nest density.

Sizes of mixed clutches

A striking feature of the sizes of the mixed clutches (see Appendix) is the frequent occurrence of single eggs of one of the two species. This was the case in 36 (90%) of the 40 mixed clutches. The normal clutch size of gulls and Common Tern is three, Arctic Tern two to three, Oystercatcher and Shag three to four, Eider four to five and Merganser eight to ten (Cramp 1977, 1983 and 1985). Another notable aspect (see Appendix) was that, in most of the mixed clutches (between 28 and 35, depending on which value one takes as the normal clutch size of Oystercatcher, Shag and Eider), neither species had a complete clutch of its own eggs. In many cases, an apparently full (mixed) clutch was attained by the inclusion of one egg of another species; in only a few instances did the total number of eggs exceed the normal clutch size of either species.

Most of the forty examples contained unequal numbers of eggs of the two species involved (see Appendix). Of the nine cases with equal numbers, eight were 1+1 and one was 2+2.

Miscellaneous observations

Much remains unknown about why birds behave in this way, but the following observations provide some insights into the formation and outcome of mixed clutches.

1) A nest marked with a numbered stake held three Common Gull eggs and one Oystercatcher egg on 10 and 15 May, two and one on 28 May, and two Common Gull eggs on 1 June. At the same colony, a similarly marked nest contained two Common Gull eggs and one Oystercatcher egg on 15 May, and three Common Gull eggs on 21 May. Both these nests were seen to be incubated by Common Gulls. The reasons for the disappearances of the Oystercatcher eggs were not established.

2) At a Shag-Herring Gull colony, a Shag was seen to fly from a Shag nest containing three Shag eggs and one Herring Gull egg. The latter was hatching, the Herring Gull chick beginning to struggle out of its fully opened shell. This strongly suggests that it had been incubated to hatching by the Shag.

3) Four of the seven Common Gull-Black-headed Gull clutches (2+1, 2+1, 2+1 and 2+2 eggs) were within a few metres of each other at a single colony on a single day; similarly, two (4+1, 2+1) of the six Eider-Herring Gull clutches were within a few metres of each other at one colony, and two (3+1, 2+3) were close to each other at another colony. These examples suggest that one individual Black-headed Gull and two individual Herring Gulls may have been responsible at these three colonies.

In these, as in many of the mixed clutches recorded in this work, the host (the species incubating the clutch and, presumably but not necessarily, the species with the greater number of eggs) and the guest species (with the smaller number of eggs) could not be certainly identified; although Eider nests are lined with down before the clutch is complete, early Eider nests are unlined and not unambiguously distinguishable from early Herring Gull nests. Similar considerations apply to many of the other species-pairs, and in only a very few cases was the species of the incubating bird established by observation.

4) Single eggs of one species were regularly seen in otherwise empty nests of another species. This was obvious when conspicuous nests were involved, such as single tern eggs in nests of Black-headed Gulls. (Some amusing combinations were seen, such as a single Arctic Tern egg centrally in the empty nest of a Mute Swan *Cygnus olor*.) This phenomenon would have been much less obvious when it involved empty nests of species with little or no nest material and, for that reason, it was not routinely recorded. However, it may be one way in which mixed clutches are formed.

DISCUSSION

Causes of mixed clutches

Explanations of the formation of mixed clutches at seabird colonies of this type should be consistent with the findings outlined above, and particularly with the following three facts. First, most mixed clutches contained only one egg of one of the two species. Second, most mixed clutches contained a total number of eggs equal to the normal clutch size of the species with the greater number of eggs, presumably the host species. Third, lapses in nest attendance and incubation by the host, allowing the guest to lay its egg and form a mixed clutch, are more likely to occur while the host's clutch is incomplete than when it has laid a complete clutch of its own eggs and begun proper incubation.

These together suggest that mixed clutches at seabird colonies originate as follows. Two birds are simultaneously laying and one, the guest, is not yet firmly attached to a nest site of its own. It mistakenly identifies the nest of the other bird, the host, as its own and lays a single egg in it; the host nest may have been empty or may already have contained an incomplete clutch. The host then lays sufficient eggs to bring the total number in the nest up to its usual clutch size. The mistake may be repeated but it becomes increasingly difficult for the guest to lay further eggs as the host begins full incubation; thus usually only one guest egg is laid. It is understandable that such mistakes should be more frequent in dense colonies and when two species with eggs of similar size are involved.

Frequency of mixed clutches

The overall frequency of mixed clutches of 0.15%, although perhaps higher than might have been expected, is a minimum figure. This is partly because my ability to identify mixed clutches may have increased over the six years (the results in Table I support this suggestion), but also because this figure does not include mixed clutches between species with very similar eggs, for example Shag-Cormorant *Phalacrocorax carbo*, Herring Gull-Lesser Black-backed Gull *Larus fuscus*, and Common Tern-Arctic Tern. Cormorants and Lesser Black-backs were breeding at some of these colonies and, although suspected mixed clutches of each of these three combinations were seen, in no case could it be definitely established that they were not single-species. Thus any mixed clutches between species with very similar eggs will have been omitted from the frequency figures given above because they were so hard to identify.

Fate of mixed clutches

The outcomes of these mixed clutches were not followed systematically but, from the few observations, it is clear that some were "corrected" at an early stage of incubation (the Common Gull-Oystercatcher examples), while others were incubated to hatching (the Shag-Herring Gull example). In cases such as the latter, it is unlikely that the guest chick would behave correctly to obtain food from the host adult, so probably it would either die early or be eaten.

However, there is on record a remarkable case of a pair of Common Terns rearing a Herring Gull chick to flying. Kuhlmann (1939) replaced a clutch of three Common Tern eggs by a single Herring Gull egg on the point of hatching. It was hatched and fed by the adult terns until the age of 64 days, when it was flying well, and it survived until at least 79 days old. This case shows that, even if the methods by which the adults feed the chicks are dissimilar, intergeneric chick-rearing can succeed among seabirds.

Interspecific mixed clutches in other bird groups

Mixed clutches have been observed at seabird colonies previously: for example, Doyle & Gough (1995) recorded a mixed clutch of Arctic Skua *Stercorarius parasiticus* and Common Gull, while Richards (1964) recorded one of Fulmar *Fulmarus glacialis* and Herring Gull.

Interspecific mixed clutches have been recorded from several other bird groups. They occur

regularly among woodland species using nestboxes (tits and flycatchers). There are records of Blue Tits *Parus caeruleus* incubating, feeding and fledging, together with their own offspring, those of Collared Flycatcher *Ficedula albicollis* (Merila 1994) and of Pied Flycatcher *F. hypoleuca* (Magnusson 1989). Mixed clutches also occur regularly among waders: a mixed clutch of Temminck's Stint *Calidris temminckii* and Common Sandpiper *Actitis hypoleucos* failed to hatch (Breiehagen 1983). An Oystercatcher incubated, hatched and fed its own young together with that of a Lapwing *Vanellus vanellus* (Hampshire & Russell 1993); the outcome of another mixed clutch involving these two species was unknown (Speakman 1987). Mixed clutches are well known among waterfowl, as documented by Amat (1991), who also recorded his finding that a remarkable 31% of 62 nests of Mallard *Anas platyrhynchos* had been parasitised by Red-crested Pochard *Netta rufina*.

Intraspecific mixed clutches

Intraspecific nest parasitism is a well-recognised phenomenon in many bird groups (e.g. Payne 1977; Yom-Tov 1980; MacWhirter 1989; Feare 1991).

In seabird colonies one commonly sees eggs that differ slightly in colour, marking, shape or size from others in the same nest. It is known that the third egg of some seabird species differs in appearance from the first two eggs in a clutch (Gochfeld 1977; Kilpi & Byholm 1995). However, such variability within a clutch may also sometimes arise if two birds of the same species have laid there. If, as suggested above, interspecific mixed clutches originate when a laying bird wrongly identifies a nest or incomplete clutch as its own, intraspecific mixed clutches are likely to be considerably more frequent than interspecific ones, although much more difficult to recognise except by modern techniques such as DNA "fingerprinting".

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SUMMARY

Between 1990 and 1995, clutch sizes and compositions were recorded at seabird colonies at 120 sites, mostly islands, in west Scotland. A total of 26,305 clutches were examined belonging to ten species: Shag, Eider, Red-breasted Merganser, Oystercatcher, Black-headed Gull, Common Gull, Herring Gull, Great Black-backed Gull, Common Tern and Arctic Tern. In total, forty clutches (0.15%) contained the eggs of two of these species, the annual figures varying between 0.03% and 0.24%. The five species most frequently involved were Common Gull (occurred as one of the two species in a mixed clutch 21/80 times), Oystercatcher (15/80), Eider (11/80), Black-headed Gull (11/80) and Herring Gull (10/80), these five species together forming 68/80 (85%) of all occurrences. Some species, especially Oystercatcher and Eider, occurred in mixed clutches significantly more frequently than they occurred in the sample of normal clutches examined. The species-pairs most frequently involved in mixed clutches were Common Gull-Oystercatcher (8/40 mixed clutches), Common Gull-Black-headed Gull (7/40), Herring Gull-Eider (6/40), these three pairs together forming over half of the mixed clutches seen. Species with eggs of similar size formed mixed clutches more often than those with eggs of very different size. Mixed clutches were more frequent when nest density was high, but island size did not have a significant effect. The great majority (90%) of mixed clutches contained only a single egg of one of the two species involved.

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J.C.A. Craik, Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, P.O. Box 3, Oban, Argyll PA34 4AD, Scotland.

APPENDIX

The numbers of eggs of each species in each of the mixed clutches recorded in this work were as follows. Each line represents a mixed clutch.

<i>Year</i>	<i>Species</i>	<i>No. of eggs</i>	<i>Species</i>	<i>No. of eggs</i>
1990	Common Gull	3	Oystercatcher	1
	Common Gull	2	Oystercatcher	1
	Common Gull	2	Eider	1
	Black-headed Gull	1	Common Tern	1
1991	Oystercatcher	3	Common Gull	2
	Oystercatcher	1	Common Gull	1
	Oystercatcher	2	Common Gull	1
	Eider	2	Common Gull	1
	Black-headed Gull	1	Common Tern	1
1992	Oystercatcher	2	Common Gull	1
	Black-headed Gull	2	Oystercatcher	1
	Oystercatcher	3	Black-headed Gull	1
	Eider	5	Herring Gull	1
	Oystercatcher	3	Great Black-backed Gull	1
	Oystercatcher	2	Common Tern	1
	Common Gull	2	Common Tern	1
	Black-headed Gull	2	Common Gull	1
1993			Black-headed Gull	1
1994	Common Gull	3	Oystercatcher	1
	Common Gull	2	Oystercatcher	1
	Common Gull	1	Oystercatcher	1
	Herring Gull	2	Eider	1
	Herring Gull	2	Herring Gull	1
	Eider	4	Herring Gull	1
	Eider	2	Arctic Tern	1
	Eider	1	Red-breasted Merganser	3
	Eider	5	Common Tern	1
	Oystercatcher	3	Common Tern	1
	Oystercatcher	1	Black-headed Gull	2
	Common Gull	2	Black-headed Gull	1
	Common Gull	2	Black-headed Gull	1
	Common Gull	2	Black-headed Gull	1
1995	Common Gull	2	Black-headed Gull	1
	Common Gull	2	Herring Gull	1
	Common Gull	1	Herring Gull	1
	Common Gull	2	Arctic Tern	1
	Herring Gull	3	Eider	2
	Eider	3	Herring Gull	1
	Eider	1	Great Black-backed Gull	1
	Shag	3	Herring Gull	1

Changes in the breeding distribution and numbers of Kittiwakes *Rissa tridactyla* around Unst, Shetland, and the presumed role of predation by Great Skuas *Stercorarius skua*

M. Heubeck, R.M. Mellor and P.V. Harvey

INTRODUCTION

Since 1981, and particularly since 1985-87, the breeding population of Kittiwakes *Rissa tridactyla* in Shetland has declined substantially (Heubeck & Mellor 1994). Within this overall trend there have been instances of rapid local increases and some new colonies formed, often near colonies where large decreases have occurred concurrently, suggesting immigration of breeding adults from declining colonies. Such presumed movements of established breeders were thought to have been due to the disturbance caused by persistent predation at declining colonies, one notable example being in Unst, where predation by Great Skuas *Stercorarius skua* was thought to have contributed to a decrease in numbers of Kittiwakes breeding at Hermaness at the same time as increases were recorded at some other breeding stations nearby (Heubeck & Mellor 1994). However breeding numbers in Unst, which in 1981 comprised 9% of those in Shetland (Richardson 1985), had not been surveyed since 1991 and so the recent situation was unknown. This paper reports on a survey that the authors made of Unst breeding stations in 1995 and reviews information on Kittiwake breeding numbers and distribution there.

METHODS

These were as described previously (Richardson 1985, Heubeck & Mellor 1994). All apparently suitable cliff habitat for Kittiwake nesting was surveyed from a Zodiac inflatable boat. The location of each colony was marked onto 1:10,000 maps at the time, and apparently occupied nests (AONs), defined as well built nests capable of holding eggs, were counted. Trace nests (either partially built, or partially disintegrated AONs) were distinguished on the 1987, 1991 (at some colonies only) and 1995 surveys. In practice, there is a continuum in the state of nests, from a few scraps of material to an obvious AON containing eggs or young; when only AONs were recorded the count will have included an unquantifiable proportion of nests that would otherwise have been recorded as traces, while the least substantial nests will have been ignored. Thus only surveys where AONs and trace nests were distinguished were strictly comparable; analyses and comparisons were of the total number of nests counted. Colonies were defined as groups of nests that were clearly separable on 1:10,000 maps and so could be identified by different observers on subsequent visits; breeding stations refer to groups of colonies with less than a mile of unoccupied coast between them, or in the case of islands, separated from the nearest colony by less than a mile of sea. Colonies are described as being in 'protected' or 'open' situations. This refers to cliff topography and a subjective assessment of the vulnerability of the colony to aerial predators, particularly Great Skuas. Protected situations were inside narrow geos (geo is the Shetland name for a gully, cleft or deep indentation in a cliff-line) or cave entrances, or with rock stacks immediately to seaward, while open situations were on relatively straight stretches of cliff with an open horizon to seaward.

RESULTS

Surveys were carried out on 24 June (Saxavord and colonies to the east) and 3 July 1981 (Hermaness and colonies to the south), 15 June 1987, 23 June 1991, and 1 June 1995. Sea conditions were calm with little or no swell on each survey. Changes in numbers of nests at individual breeding stations are described below, clockwise from the south-west (Figure 1).

Four colonies were found at Blue Mull in 1981, all set low on 20-30 m high cliffs. The number of nests declined by 27% between 1981-87, and then more rapidly so that only two colonies

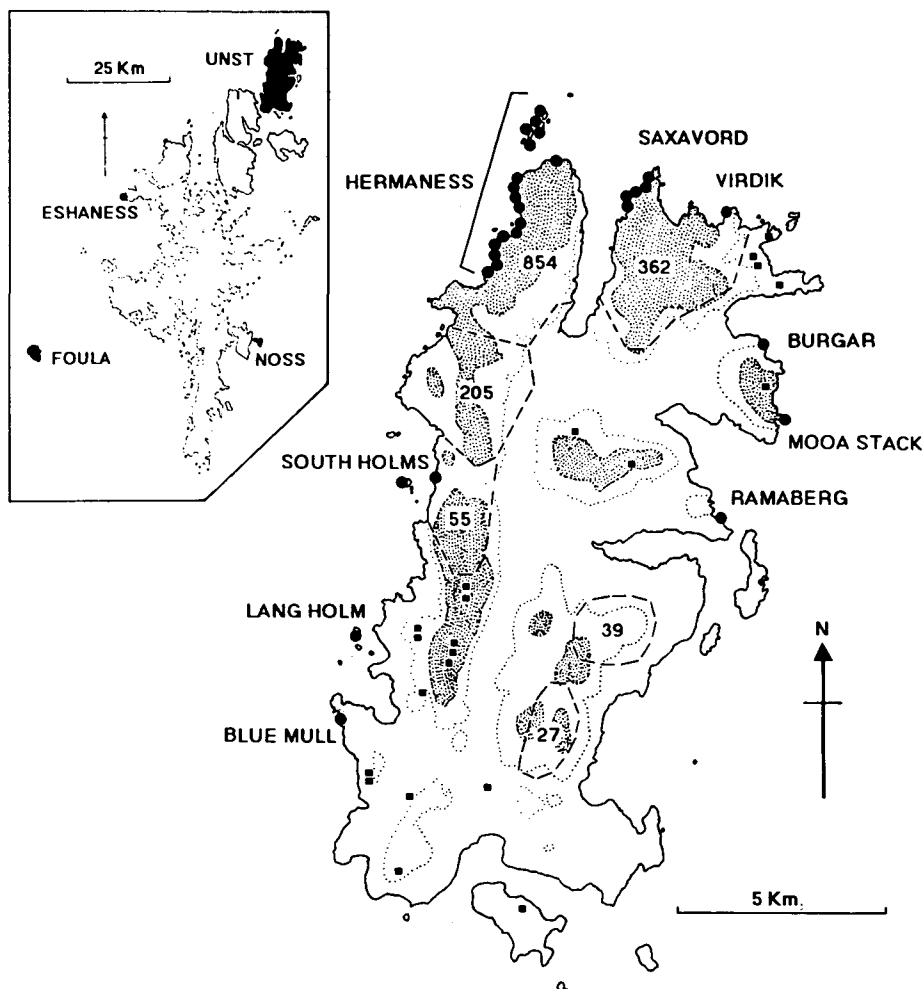


Figure 1. Map of Shetland (inset) showing the location of Unst and other places mentioned, and map of Unst showing the location and extent of Kittiwake breeding stations (solid circles, some adjacent colonies are indicated by one circle), the 50m contour (dotted line) and land over 100m (stippled), and the distribution and number of Great Skua apparently occupied territories in 1992 (numerically within dashed lines, solid squares indicate single territories, data from Sears *et al.* 1995 & RSPB unpublished).

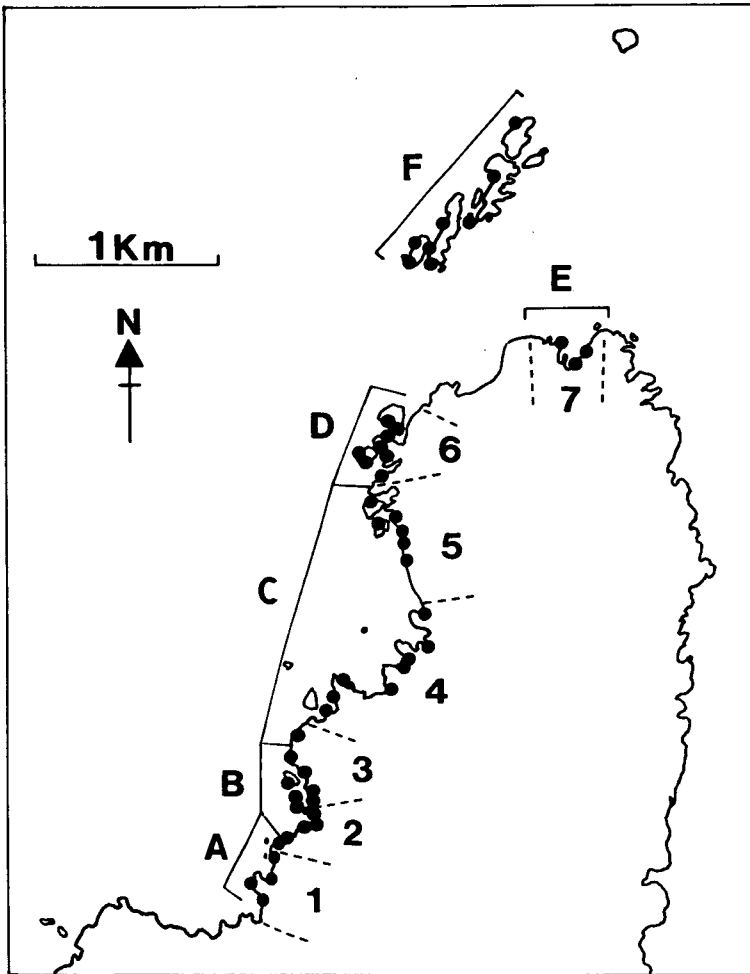


Figure 2. Map of Hermaness showing the location of Kittiwake colonies during 1981-95 (solid circles) and the groups of colonies used for comparisons of counts of nests made from the sea (A-F, Table I), and from land (1-7, Table III).

remained extant by 1995, the larger (23 nests) over a cave entrance at the back of a deep, narrow geo. The small colony present on a 10 m high open cliff-face on Lang Holm in 1981 had almost disappeared by 1987, and had done so by 1991.

Three colonies in highly protected locations have been recorded at South Holms, two on a 20 m high cliff in a narrow geo at South Holms and one 0.9 km to the east on a 60 m cliff protected by the large Gamli Stack. The number of nests increased markedly at all three of these sites between 1981-87 but the smaller South Holms colony (43 nests in 1987) had disappeared by 1991 and the

other had decreased from 128 to 6 nests (and 5 in 1995). The colony inside Gamli Stack decreased from 144 nests in 1987 to 65 in 1991 and none by 1995.

Hermaness, the fourth largest breeding station in Shetland, comprised (in 1981) 43 colonies along the cliffs of Hermaness itself and 8 on the Muckle Flugga stacks, 0.6-1.1 km offshore. Changes in numbers have differed within the breeding station and to illustrate this colonies were grouped into six sections (A-F, Figure 2).

The five colonies recorded in section A in 1981, all in deep geos or around cave entrances, were still extant in 1995. The total number of nests here increased by 43% between 1981-87, then decreased slightly by 1991 but more rapidly by 1995. In section B, apart from three small colonies on low stacks and one in a geo that was presumed overlooked in 1981 (100 nests in 1987), most colonies were in rather open situations and compared to other Hermaness colonies many nests were relatively high up the 160 m cliffs. This section of Hermaness experienced the greatest numerical (1167) and proportional (-91%) reduction in nests between 1981-95 (1325 nests and -92% allowing for the colony overlooked in 1981, see Table I), the most rapid rate of decrease being between 1987-91.

Of the small colonies in section C (none were known to have exceeded 62 nests) the nine southern ones were either in the back of deep geos or protected by offshore stacks, while the six northern ones were in open situations on 80 m high cliffs. Although there was an overall decrease between 1981-87, the number of nests actually increased at the six southernmost colonies (from 153 to 218), but decreased from 130 to 20 at the more open northern colonies. There was a more general decrease between 1987-91, by which time eight of the colonies had disappeared, and a further slight decrease by 1995.

Most colonies in section D were in rather protected situations on opposing faces of four c.50 m high stacks. One colony, which held 275 nests in 1987, was overlooked in 1981 and there was probably only a slight overall decrease between 1981-87 (Table I), with a further moderate but steady decline by 1995. Of three small colonies in section E (two relatively protected, one more open), the 'open' one disappeared between 1981-87 but another increased from 26 to 59 nests; numbers then decreased markedly by 1991 (as in most other sections), with little change by 1995. Some colonies on the 30-50 m high stacks of Muckle Flugga (section F) were in very open situations but some were highly protected. Adverse sea conditions in 1981 caused one colony to be overlooked, and another was noted as "probably severely undercounted". Given this there was probably only a slight decrease between 1981-87, more marked by 1991, but again only slight between 1991-95 by which time two colonies had disappeared.

Thirteen colonies have been recorded along the 100-140 m high cliffs of Saxavord, seven in relatively open situations; more than 40 nests were recorded at only 2 colonies and most of the other 11 comprised less than 10 nests in some years, or were occupied intermittently. In addition to counts in Table I, 186 AONs in seven colonies were recorded by the NCC on 26 June 1985 using comparable methods. The most notable change was at a colony beside a cave entrance (Hols Hellier) where there were two nests in 1981, 112 in 1985, 345 in 1987, and 429 in 1991. In 1995 there were only 44 nests, of which 39 were empty.

There was little change between 1981-87 at Virdik, set on an open 70 m high cliff, but a substantial decrease thereafter. Of three colonies at Bugar, all in only moderately protected situations along a 400 m stretch of 50 m high cliffs, one was deserted between 1981 (85 nests) and 1987, while the other two increased by 79 nests. Between 1987-91 the smaller colony decreased (by 41 nests) and the larger increased further (by 20 nests), but there was little change at either by 1995. The Mooa Stack colony, in an open situation over a 10 m high cave entrance, increased between 1981-87, decreased slightly by 1991 and then more rapidly by 1995. The Ramaberg colony, established in 1989 (M. Pennington pers.comm.) on an open 25 m high cliff was presumably overlooked on the 1991 survey (the nest count in Table I was made from land); it increased to 40 nests in 1994 (M. Pennington pers.comm.) and 88 in 1995.

TABLE I. THE NUMBER OF COLONIES, AONs AND TRACE NESTS RECORDED ON FOUR SURVEYS OF KITTIWAKE BREEDING STATIONS IN UNST, AND THE PERCENTAGE CHANGE PER ANNUM BETWEEN SURVEYS IN TOTAL NUMBERS OF NESTS (ITALICS). *THREE COLONIES AT HERMANESS WERE PRESUMED OVERLOOKED IN 1981. HAD 1981-87 CHANGES AT THOSE COLONIES OCCURRED AT THE SAME RATE AS AT OTHERS IN THEIR SECTIONS, 1981 AON COUNTS AND 1981-87% P.A. CHANGES WOULD HAVE BEEN AS INDICATED IN SQUARE BRACKETS.

<i>Breeding Station</i>	<i>1981</i>		<i>1987</i>		<i>1991</i>		<i>1995</i>
Blue Mull : Colonies	4		3		2		2
AONs (trace nests)	158	-5%	114 (1)	-7%	87	-26%	21 (5)
Lang Holm : Colonies	1		1		0		0
AONs (trace nests)	32	-32%	2 (1)		0		0
South Holms : Colonies	3		3		2		1
AONs (trace nests)	121	+17%	305 (10)	-31%	71	-48%	5
Hermaness, A : Colonies	5		5		5		5
AONs (trace nests)	232	+6%	319 (12)	-3%	288	-13%	151 (12)
B : Colonies	10 *		10		8		7
AONs (trace nests)	1275	-5%	787 (120)	-29%	246	-19%	103 (5)
	[1433	-6%]					
C : Colonies	15		8		7		6
AONs (trace nests)	330	-4%	238 (10)	-11%	158	-3%	139 (1)
D : Colonies	8 *		8		8		8
AONs (trace nests)	1715	+1%	1829 (39)	-6%	1429	-6%	1026 (77)
	[2011	-1%]					
E : Colonies	3		2		1		2
AONs (trace nests)	54	+3%	61 (5)	-21%	25	-4%	20 (1)
F : Colonies	7 *		8		7		6
AONs (trace nests)	266	+<1%	263 (5)	-14%	140 (8)	-7%	96 (12)
	[307	-2%]					
Total : Colonies	48 *		41		36		34
AONs (trace nests)	3872	-<1%	3497 (191)	-11%	2286 (8)	-8%	1535 (121)
	[4367	-2%]					
Saxavord : Colonies	11		10		10		6
AONs (trace nests)	141	+22%	432 (30)	+3%	447 (77)	-28%	129 (8)
Virdik : Colonies	1		1		1		1
AONs (trace nests)	84	-<1%	72 (7)	-26%	23 (6)	-20%	10 (2)
Burgar : Colonies	3		2		2		2
AONs (trace nests)	217	+<1%	211 (10)	-2%	196 (4)	-<1%	193 (6)
Mooa Stack : Colonies	1		1		1		1
AONs (trace nests)	53	+10%	92 (5)	-7%	67 (4)	-23%	25
Ramaberg : Colonies			established in 1989		1		1
AONs (trace nests)					3	+76%	79 (9)
UNST TOTAL : Colonies	72 *		62		55		48
AONs (trace nests)	4678	+<1%	4725 (255)	-10%	3185 (99)	-10%	1997 (151)
	[5173	-<1%]					

These surveys involved only brief visits to each colony, and so any evidence of predation by Great Skuas was circumstantial. Skuas tend not to prey upon nests randomly at breeding stations but target particular colonies or parts of colonies, which by late incubation and early fledgling stage (when the 1981, 1987 and 1991 surveys were made) can result in distinct clusters of empty and usually partly disintegrated nests (Heubeck & Mellor 1994, pers.obs). This was particularly obvious in 1987 at three adjacent colonies in section C of Hermaness, and in 1991 at the Hols Hellier colony at Saxavord; in both cases subsequent surveys recorded considerable reductions in the number of nests (Table II).

DISCUSSION

The number of Kittiwakes breeding in Unst decreased by 54-58% between 1981-95. This was almost twice the proportional decrease in the overall Shetland population over roughly the same period, thought to have been due to a combination of reduced abundance of sandeels during 1984-90 (Wright & Bailey 1993) resulting in low breeding success and few recruits to the breeding population (Hamer *et al.* 1993), and increased predation by Great Skuas from the mid-1980s onwards (Hamer *et al.* 1991, Heubeck & Mellor 1994).

TABLE II. COUNTS OF NESTS AT KITTIWAKE COLONIES WHERE A LARGE PROPORTION OF EMPTY OR DESERTED NESTS (IN 1987 AT HERMANESS AND 1991 AT SAXAVORD) WAS SUGGESTIVE OF EXTENSIVE PREDATION; ACTIVE = ADULT INCUBATING OR BROODING, EMPTY = WELL BUILT BUT ADULT STANDING ON THE RIM AND NO EGGS/CHICKS SEEN, TRACE/DESERTED = UNATTENDED, SOME PARTLY DISTINTEGRATED. ACTIVE AND EMPTY NESTS WERE NOT DISTINGUISHED IN 1981.

	<i>Hermaness, section C (3 colonies)</i>			<i>Saxavord, Hols Hellier colony</i>		
	<i>Active</i>	<i>Empty</i>	<i>Trace/deserted</i>	<i>Active</i>	<i>Empty</i>	<i>Trace/deserted</i>
1981	584			2		
1987	201	76	105	318	19	8
1991	4	4	233	128	68	
1995	1	2	3	5	39	

While both these factors will have affected breeding numbers in Unst, the relative significance of low breeding success was probably less here than in other parts of Shetland. During the years when sandeel abundance and their availability to seabirds was low, Kittiwakes maintained moderate breeding success in north-west Shetland and even in 1990, when virtually no chicks fledged at colonies in east and south-west Shetland (Heubeck 1991), a mean of 0.47 young fledged per AON at two Hermaness study plots (Walsh *et al.* 1991). By the mid-1990s this situation had reversed, with breeding success being moderate to high at some colonies in southern Shetland but low at both Hermaness plots, thought largely due to predation by skuas (Rowse 1995, Heubeck 1996).

The decrease in breeding numbers at some large Hermaness colonies (section B) and the coincident increases during the early 1980s at the smaller but physically more protected colonies to the north (C and E) and south (A) and, more notably, at the nearest breeding stations to the east (Saxavord) and south (South Holms), suggested movement of established breeding adults. That the breeding population of Unst only decreased by c.4-500 pairs between 1981 and 1987 (less than 1% per annum) also tends to support this. The long-term study of a Kittiwake colony on a North Shields warehouse (where no predation of nests occurs) found that once established as breeders, birds almost never then moved colonies, a significant exception being in the years following disturbance from illegal shooting (Coulson & Nève de Mévergnies 1992). However,

throughout their range Kittiwake colonies naturally suffer varying degrees of predation from different birds and mammals (Burger & Gochfeld 1984, Walsh & McGrath 1989, Hatch *et al.* 1993a), and other studies of colour-ringed birds in Brittany (Danchin & Monnat 1992) and Alaska (Hatch *et al.* 1993b) found that a low level of inter-colony movement probably does occur normally. In Brittany this level increased markedly in the years following heavy predation of chicks by Carrion Crows *Corvus corone*, and massive desertion of other colonies in the area was observed after intense predation of eggs and chicks (Danchin & Monnat 1992). Desertion of small colonies following predation by corvids has also been both observed and suspected in south-west Norway (Munkejord & Folkedal 1981, Godø 1985). Ravens *Corvus corax* and Hooded Crows have long been known to prey upon Kittiwake eggs in Shetland, including on Unst (Saxby 1876), but the impact on colonies is believed to be highly localised and transitory, presumably as specialist individuals die, with no evidence of any recent increase in its occurrence (Heubeck & Mellor 1994). Hooded Crows only breed intermittently at Hermaness but 3-5 pairs of Ravens nest on the headland (Pennington *et al.* 1991). Whether Ravens have preyed upon Kittiwake eggs at Hermaness is unknown, although such behaviour or the finding of egg-shell dumps has not been mentioned in wardens' annual reports; the most likely predator to have prompted breeding Kittiwakes to shift to other colonies is the Great Skua.

North Unst holds the second largest concentration of breeding Great Skuas in Shetland (Figure 1), their numbers on the island having increased from a handful of pairs in the 1890s (Evans & Buckley 1899) to 1,228 pairs by 1974/75 (Everett 1982) and 1,567 apparently occupied territories in 1992 (Sears *et al.* 1995). The first recorded observation of Great Skua predation on Kittiwakes at Hermaness was in 1950 when they were found to have taken eggs, chicks, fledged young and (probably) adults (Lockie 1952), while Venables & Venables (1955) cite anecdotal evidence suggesting extensive predation of Kittiwake chicks at Muckle Flugga around this time.

In late July and early August 1972 Andersson (1976) studied predation at colonies in section B of Hermaness (he found this was the part of the breeding station most frequented by skuas). He saw no adults killed (although carcasses near skua nests suggested they had been earlier in the season) but saw 18 chicks taken by Great Skuas during 124 hours of observation of c.900 nests,

TABLE III. COUNTS FROM LAND OF KITTIWAKE AONs AT HERMANESS (EXCLUDING MUCKLE FLUGGA). AREAS ARE SHOWN IN FIGURE 2. DATA FROM: 1965 (DOTT 1967), 1969 (OPERATION SEAFARER RECORD CARDS), 1974 (ALBON *ET AL.* 1976), 1978-1991 (SOTEAG UNPUBLISHED). FIGURES IN BRACKETS INDICATE +/- ACCURACY OF COUNTS. * SOME COLONIES IN AREA 1 MAY HAVE BEEN OVERLOOKED IN 1974, AND THE TOTAL COUNT OF NESTS DIFFERS FROM THE 3,952 CITED BY HARRIS (1976).

Year	1965	1969	1974*	1978	1985	1989	1991
Date	18/6-1/7	29/6-15/7	6-11/6	29/6-17/7	9-21/6	5-9/6	6-15/6
Area							
1		208	78	88		98	124
2	2170 (550)	1165 (100)	905	204	1009	141	77
3		990 (110)	559	220		101	42
4		79	71	20		10	22
5	470 (100)	258 (40)	234	49	75 + 21	0	4
6	650 (100)						
7		2206 (60)	2017	1100 +	853	640	870
	13	16	24	1	0	0	0
Total	3303 (730)	4922 (310)	3888	1682	1958	990	1139

estimating 0.12-0.14 chicks taken per nest during the breeding season. He thought breeding success (estimated at 0.87-1.06 chicks fledged per pair) was only slightly reduced by this level of predation and since he counted 1,050 nests in the area where 800-900 were reported in 1959 (Coulson 1963), concluded there was little evidence of a marked decrease in breeding numbers. However, counts made from land in the 1960s suggest breeding numbers may already have begun to decrease at Hermaness by the early 1970s, particularly at those colonies Andersson observed (Table III).

The Hermaness colonies are not easy to count from land. Many are not visible or are only partly visible from the cliff top, while others can be viewed only from a considerable distance. The proportion of nests observed therefore depends to an unquantifiable extent on the willingness of observers to scramble down cliffs to better vantage points. Furthermore, some counts (including Andersson's) were made late in the season, by which time an unknown proportion of breeding attempts will have failed and nests disappeared. The location of colonies was not mapped in 1969, 1974 and 1978 but nest counts were summed for the same sections of cliff, which differed only slightly from those used for counts from the sea (Figure 2).

Some 660-1280 fewer nests were counted in 1974 than on considerably later dates in 1969, with the greatest percentage decreases being in sections 2 and 3, the general area of Andersson's study and the area most frequented by skuas in 1972 (Table III). Although counts in 1978 were made late in the breeding season, and those at the southernmost colonies were imprecisely mapped in 1985, there was a considerable anomaly between the two surveys in nest totals in sections 1, 2 and 3. This could be explained by a) a high proportion of nests being overlooked in 1978, b) breeding numbers increasing between 1978 and 1985, or c) a high rate of nest failure in one or more of these sections in 1978 meant many nests had disintegrated by the time of the survey (11 July) and so were not recorded. The first is unlikely as the 1978 counts were made by three experienced observers, and the second is also unlikely since counts from the sea indicated decreases at these colonies between 1981-87. In view of the 1969-74 decreases in sections 2 and 3, the last seems a likely, albeit circumstantial, explanation. If so, this suggests that predation of nests by skuas may have been affecting Kittiwake breeding numbers at Hermaness as early as the mid-1970s.

Elsewhere, the impact of skua predation on Kittiwake numbers and breeding success on Foula in the mid-1970s was considered negligible (Furness 1979), although it had long been known to occur (Venables & Venables 1955), and it was predicted that if there was a serious decline in sandeel abundance close to seabird colonies, predation rates would increase and Kittiwakes would be one species to suffer particularly (Furness 1981). As sandeel abundance indeed decreased during the 1980s, so skua predation on other seabirds increased markedly throughout Shetland, as indicated both by analysis of regurgitated pellets (Harvey *et al.* 1989, Hamer *et al.* 1991) and by many anecdotal accounts (Riddiford & Silcocks 1988, Furness 1989, Heubeck 1992). The only recent quantification of skua predation rates was at a colony of c.1,000 nests at Eshaness in early July 1988, when 12 Kittiwakes were killed in 18 hours of observation (SOTEAG unpubl.), a rate c.5 times that observed by Andersson (1976) at Hermaness. Predation of eggs, chicks and adults at this colony has intensified greatly since 1988; no young survived to fledge in 1994 or 1995, and breeding numbers declined by c.60% between 1989 and 1995 (pers.obs).

There is a feeling among seabird workers in Shetland that despite increased sandeel abundance from 1991 onwards (Anon. 1995) predation of seabirds by skuas continued to increase during the 1990s. However, as yet there has been no widespread, rigorous study of the phenomenon and it is not known whether any increased level of predation has been due to the habit having spread among the skua population, or increased rates of predation by specialist individuals. By 1995 differences among sites in the intensity of predation by Great Skuas was thought to be responsible for the wide variation in both breeding success and trends in numbers, at Kittiwake colonies throughout Shetland (Furness 1995, Heubeck 1996), and was considered a major factor in the

61% decrease since 1981 in breeding numbers on Noss, another major Great Skua breeding colony, after a decade of stability (Goddard & Hemsley 1995). In these circumstances the Unst colonies, and particularly those at Hermaness, are unlikely to regain their former size in the foreseeable future.

Factors not considered here may also have influenced the breeding numbers and distribution of Kittiwakes in Unst over the past 20 years, and we acknowledge that evidence for the implied role of predation by Great Skuas is almost entirely circumstantial. Whether skuas were involved in the decline of the colonies at South Holms (despite their seemingly highly protected situation) and Hols Hellier, Saxavord is unknown, although we believe it likely given their proximity to large numbers of skua territories and the high proportion of empty and deserted nests seen at Hols Hellier in 1991. The overall impression has been that the effect of skua predation on Kittiwake numbers was first manifested at colonies in unprotected situations close to major breeding concentrations of skuas and that after birds had moved to colonies in more protected and/or more distant situations, some of those colonies then were either "found" by, or became more attractive to, predatory skuas as they grew in size. It will be interesting to follow the fate of the recently established breeding station at Ramaberg, as far away from large skua colonies as one can get on Unst but in a very exposed situation.

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SUMMARY

Counts of nests from the sea found breeding numbers of Kittiwakes in Unst to have declined by 54-58% between 1981-95, from c.5,000 to c.2,000 nests. At Hermaness, the largest breeding station on Unst, the greatest numerical and proportional decrease occurred at colonies along cliffs where in 1972 the greatest level of predation of nests by Great Skuas was thought to have occurred, and where counts from land suggest a decline in breeding numbers began in the early 1970s. Between 1981 and 1987 there was an increase in the number of nests at smaller and physically more sheltered Hermaness colonies adjacent to these declining colonies, and at the nearest breeding stations to the south and east. This suggested a movement of breeding adults away from the declining colonies. Since 1987 there was a more general decrease at the Unst breeding stations.

During the 1980s Great Skua predation of other seabirds (and Kittiwakes in particular) increased in Shetland, coincident with a reduction in the abundance of sandeels, and probably continued to do so in the 1990s despite an increase in sandeel abundance. By 1995 predation by skuas appeared to be causing wide variation in Kittiwake breeding success and trends in numbers at Shetland colonies. Because Unst holds the second largest breeding concentration of Great Skuas in Shetland, it is unlikely that there will be any increase in Kittiwake numbers there in the foreseeable future.

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M. Heubeck, Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB9 2TN, UK.

P.V. Harvey, Scottish Natural Heritage, 2-4 Alexandra Buildings, The Esplanade, Lerwick, Shetland ZE1 0LL, UK.

R.M. Mellor, Fairview, Quendale, Shetland ZE2 9JB, UK.

Population status of Storm Petrels *Hydrobates pelagicus* on islands off north-west Scotland

A. R. Mainwood, N. Ratcliffe, S. Murray and G. P. Mudge

INTRODUCTION

The Storm Petrel *Hydrobates pelagicus* nests on remote offshore islands. Its nesting habitat is very diverse including boulder scree, storm beaches, rock crevices, dry stone walls and in burrows in soil or peat. The birds remain in the nest chamber during the day and the presence of a colony on an island is usually only evident at night.

The breeding population has been estimated at 20,000 to 150,000 pairs in Britain and 50,000 to 100,000 pairs in Ireland (Cramp *et al.* 1974, Lloyd *et al.* 1991). The British population represents between 15% and 40% of the world population, which is estimated at between 135,000 and 380,000 pairs (Lloyd *et al.* 1991). The British population of Storm Petrels is thus of international importance and is listed as a British Red Data Bird and is on Annex 1 of the EC Birds Directive (Batten *et al.* 1990).

Despite their international importance, the status and trends of Storm Petrel populations in Britain and Ireland is poorly known. Nocturnal, burrow nesting petrels are notoriously difficult to census and, in arriving at the above estimates, Lloyd *et al.* (1991) recognised that there was no standardised method to census breeding Storm Petrels. There is an urgent need to develop improved census techniques to allow an accurate assessment of status and trends for Storm Petrel populations.

Attempts have been made to census breeding Storm Petrels at colonies using a variety of methods. Mist netting of birds returning to the colony at night has been used to estimate relative densities of birds or to calculate population status from mark-recapture analysis (Scott 1970, Furness & Baillie 1981, Fowler *et al.* 1982). This method is complicated by the presence of large numbers of non-breeding birds and uncertainty about what proportion of the island population is being sampled.

Petrels that return to the colony at night are often very vocal and this is important for intraspecific communication (James & Robertson 1985a, Taoka *et al.* 1989a). The calls are sometimes sexually dimorphic, especially in species with aerial calling (Brooke 1978, James & Robertson 1985a, 1985b, Taoka *et al.* 1989b). In Storm Petrels, only males give a purr call while both sexes have a terr-chick call (James 1984). Mapping the location of calling birds at night has been used to estimate Storm Petrel population status on Mousa, Shetland (Ratcliffe *et al.* 1996). Only between 20% and 35% of breeding birds call on any one night (Scott 1970, Ratcliffe *et al.* 1996) so repeat surveys are required to estimate the approximate number present. This method is best used during the pre-egg stage when breeding males are purring in the burrow at night and there are few non-breeders present in the colony (Scott 1970).

The vocalisations of petrels can also be used for censusing during the day by using playback recordings to elicit responses from birds in nest sites (James & Robertson 1985c). This technique has also been applied at night on Skokholm during the pre-egg stage (Vaughan & Gibbons 1995). Not all birds will respond to playback so it is important that the response probability is investigated to estimate the number of breeding pairs likely to have been missed (James & Robertson 1985c). Males and females often have different vocalisations and response

probabilities and so calibrations should be made within sexes (James & Robertson 1985c). Response probabilities have been examined for Manx Shearwaters *Puffinus puffinus*, (James & Robertson 1985c), Leach's Petrels *Oceanodroma leucorhoa* (Taaka *et al.* 1989b) and Storm Petrels (James 1984, Ratcliffe *et al.* 1996) and so have the potential for use in census work.

This study used playback techniques to estimate the status of Storm Petrels on selected islands off the north-west coast of Scotland. These islands have not been surveyed in a systematic manner before and on some, the occurrence of breeding had not previously been established. An evaluation of the methods and suggestions for further research into playback techniques are discussed.

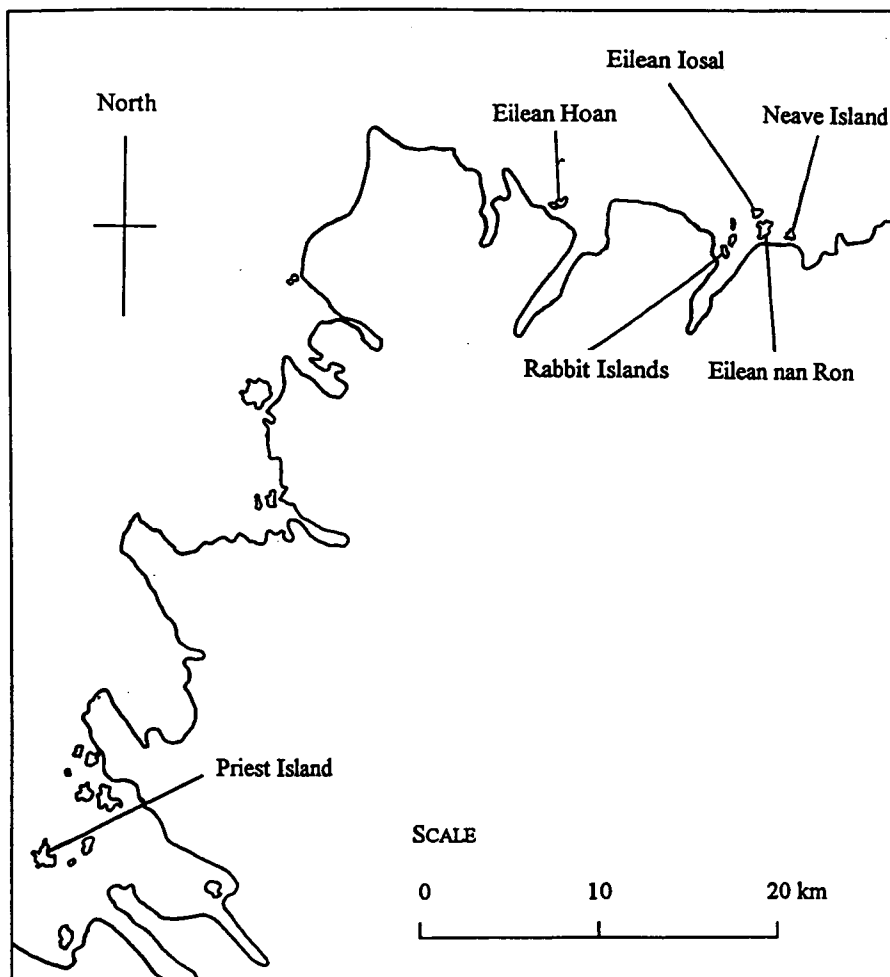


Figure 1. Map of north-west Scotland showing the islands surveyed.

METHODS

The study islands were Eilean Hoan, Eilean nan Ron, Eilean Iosal, Neave Island, and Rabbit Island off the north coast of Sutherland and Priest Island in the Summer Isles off Wester Ross, Scotland (Fig. 1).

The field work was undertaken between 15 July and 3 August 1995 to coincide with the period of peak incubation when most active nests would have an adult bird in attendance during the day. Diurnal adult attendance is erratic after the chicks are over 7 days old (Scott 1970) and chicks do not normally respond to playback (D. Suddaby, pers comm.), so nest site detectability using playback declines following the peak of incubation. The laying period in north Scotland is estimated to be between early June and early August with about 80% of eggs probably being laid between late June and late July. This was determined from latitudinal interpolation of the peak laying dates for Skokholm, Dyfed (Davis 1957, Scott 1970) and Mousa, Shetland (M. Bolton, unpublished data).

The playback method was used to both locate and census colonies. It was not possible to establish the breeding status of birds with certainty as direct examination of the nests might have led to desertion (Davis 1957). Instead the unit used for the census was an apparently occupied site (AOS), this being defined as any site that contained a bird that responded to tape playback.

The presence of birds was detected by playing the male purr call at maximum volume for 10-15s at burrow entrances or close to potential nest sites in boulders or stones. The equipment used in the survey was a personal stereo connected to a single amplified speaker delivering a 200 mW output.

On Eilean Iosal and Eilean nan Ron, 10s appeared to be sufficient to get a response, as playing the tape for longer periods did not result in more birds responding. On Priest Island it was sometimes found that a longer or second playback was needed before a response was obtained. In some of the deeper peat burrows responses could only just be heard by putting the ear to the entrance after turning the tape off. There could be a delay of 10 to 15s after the tape was stopped before a bird responded.

It was also sometimes necessary to repeat the playing of the tape when several birds responded from one burrow entrance. Individuals responding at the same time could often be distinguished by differences in the phrase of the calls, by the volume (and hence distance away) or the direction from which it came.

All suitable nesting habitats (holes in peat, cracks in rock, holes under rocks, areas of boulder scree, boulder beaches and walls or buildings) were searched systematically for AOSs and almost complete coverage of each island was achieved. Different habitats required different survey methods because nest entrances are apparent in peat burrow habitats but not in boulder and wall sites. The survey methods for each nesting habitat are outlined below.

Burrows in peat

Priest Island was systematically surveyed for areas that had at least 30cm depth of peat. Within these areas, burrows were searched for on level areas under heather *Calluna vulgaris* and blaeberry *Vaccinium myrtillus*, in peat hummocks, small landslips above cliffs, disused peat banks and under large rocks and boulders. In most cases burrows in peat were detected visually but in areas of low, dense vegetation burrows were searched for by touch. Two areas of sloping peat (approximately 15m wide) covered in mature heather (over 1m tall) on Priest Island were searched systematically by three observers moving in a line and playing the tape into any cracks or holes. If there was a clear gap of 10m or more between groups of AOSs they were classed as separate sub-colonies. Each colony was plotted on a large scale map (approximately 1:5280).

Walls and ruins

The walls and ruins on Priest Island and Eilean Hoan were censused by playback at 1m intervals,

so that the maximum distance between a potential nest site and the tape recorder was 50cm. Where the wall was thicker than 1m, both sides of the wall were surveyed. In these situations, AOSs that were thought to have been detected from both sides of the wall were only counted once. Each building was treated as a separate sub-colony and sketch maps of the location of AOSs in each building were drawn. The walls of buildings on Eilean nan Ron were constructed with mortar and those surveyed contained no petrels. Other walls on Eilean nan Ron were less than 0.5m high and were built of small stones. The gaps in the wall were too small to accommodate petrel nests and a survey of a 200m stretch produced no responses. The rest of the walls on the island were not surveyed.

Scree and boulder sites

Boulder beaches only occurred on Priest Island and none of these were very extensive. The tape was played about 50cm above the boulders at 5m intervals. Once a response was obtained a more detailed census was conducted by playing the tape at 1m intervals in a grid-line pattern until no more AOSs were detected. The survey intervals are approximate as they were judged by eye. None of the sub-colonies found in boulder beaches occupied an area more than 5m².

Inland areas of boulders were often overgrown with heather, juniper *Juniperis communis nana* and honeysuckle *Lonicera periclymenum*. These habitats were surveyed in a similar manner to boulder beaches. One area on Priest Island was a mixture of partially buried boulders and boulder scree measuring approximately 400m x 400m and was divided into 15m wide strips using rope. Each strip was surveyed by three observers working in a line, playing the tape at 1m intervals in scree or into any potential nest holes among partially buried boulders.

Rock and cave sites

Any accessible cracks in solid rock large enough to hold Storm Petrels were checked with the playback. On Priest Island a colony of Storm Petrels was found in a dark cave and some incubating birds were directly visible with a torch. Playback surveys were conducted but response probabilities were very low. The census of the cave was therefore carried out by direct observation of apparently incubating adults.

Habitats not censused

Preliminary searches of the islands demonstrated that areas covered with thin peat or grass, boggy areas and areas of solid rock with no cracks were not suitable nesting habitats for Storm Petrels and so these habitats were not surveyed systematically. The areas of bracken *Pteridium aquilinum* on Eilean nan Ron were investigated briefly but were considered unsuitable due to the height of the vegetation and the low density of holes underneath.

Estimation of the total number of AOSs

Not all the birds respond to tape playback so the number of AOSs detected needs to be corrected in order to estimate the total number of AOSs. James & Robertson (1985) suggested an equation to calculate a correction factor that can be applied to playback census data to obtain an estimate of the size of the breeding population:

$$C = \frac{1}{[M(\chi) + F(\gamma)]}$$

Where C = Correction factor, M = proportion of males present, χ = probability of a male responding to the tape, F = proportion of females present and γ = probability of a female responding to the tape.

Sex-specific attendance and response probabilities during incubation have been examined for Storm Petrels on Skokholm. Davis (1957) found that sexes share incubation equally (M = 0.5, F =

TABLE I. NUMBER OF SUB-COLONIES, PLAYBACK RESPONSES AND AOS TOTALS FOR STORM PETRELS ON ISLANDS OFF NORTH WEST SCOTLAND IN 1995.

<i>Island</i>	<i>No. of sub-colonies</i>	<i>No. of purr responses</i>	<i>No. terr-chick responses</i>	<i>Total responses</i>	<i>Total No. AOSs</i>
Eilean Iosal	4	6	36	42	57
Eilean nan Ron	35	17	105	122	166
Neave Island	0	0	0	0	0
Rabbit Islands	1	0	3	3	4
Eilean Hoan	1	3	20	23	31
Priest Island	234	490	1147	1637	2235

NB: For Priest Island the cave site was censused by a direct visual count of AOSs (25 AOSs in total).

TABLE II. FREQUENCY OF STORM PETREL SUB-COLONIES ON PRIEST ISLAND WITH A GIVEN NUMBER OF RESPONSES.

<i>Responses per sub-colony</i>	<i>Number of sub-colonies</i>	<i>% of total no. of sub-colonies</i>	<i>Total number of responses</i>	<i>% of total no. of responses</i>
1	40	17%	40	2%
2	43	18%	86	5%
3-5	66	29%	267	17%
6-9	44	19%	333	20%
10-19	24	10%	300	18%
20 +	17	6%	616	38%

0.5) and James (1984) found that all males ($\chi = 1.0$) and 46% of females ($\gamma = 0.46$) respond to playback of the purr call. Substituting these values into the equation gives:

$$C = \frac{1}{[0.50(1.00) + 0.50(0.46)]} = 1.37$$

An overall response probability (for all sexes pooled) of 0.75 was found on Mousa in 1993 (Ratcliffe *et al.* 1996). This is a similar figure to the product of the denominator in Equation 2 ($0.50 (1.00) + 0.50 (0.46) = 0.73$). A correction factor of 1.33 ($1/0.753$) can be derived from the Mousa data that is similar to the one found on Skokholm. The mean value of C from these two studies is 1.35. The number of AOSs detected during the survey was multiplied by the mean correction factor to provide an estimate of the total AOSs present on the assumption that response probabilities and attendance patterns are similar on the study island to those on Skokholm and Mousa.

RESULTS

Eilean Iosal

During the first visit only one colony was found in the cracks of a peat step near the cliff edge. A total of 39 responses were recorded giving a total of 53 AOSs for this colony. Three other single AOSs were found in holes in level peat during a second visit in August. At one nest, an adult

responded and a chick was also heard. The chick weighed 32.9g and was judged to be approximately 24 days old from comparisons with growth curves and photographs in Davis (1957). The population of Eilean Iosal was estimated as 57 AOSs (Table I).

Eilean nan Ron

A systematic search of the island coast was undertaken on 16 and 17 July. No colonies producing more than 10 responses were found. The most frequent nesting habitat was peat banks about 30cm high that were bare or overgrown with heather. One colony in an area of fissured conglomerate produced seven responses. The main colonies away from the coast were in disused peat workings to the north-east of the island. At one AOS a chick was heard calling on 18 July. A total of 35 colonies were located that produced 122 responses. The population for Eilean nan Ron was estimated as 166 AOSs (Table I).

Neave Island

A thorough coastal search was made of Neave Island in all accessible and likely habitats but no responses were obtained (Table I). None of the interior of the island was considered to be suitable for Storm Petrels as there were no areas of boulders or heather covered peat.

Rabbit Islands

Only one colony was found on the Rabbit Islands, from which three responses were recorded. This was located in a pile of boulders on the most northerly of the two islands. A visit to Sgeir an Oir (the outermost of the group) was made but no responses were recorded. The population was estimated at 4 AOSs (Table I).

Eilean Hoan

A single colony was found in the ruined walls and under a couple of large boulders near the bothy. It produced 21 responses between 08:30 and 10:00 (BST) but when re-censused about two hours later only 11 responses were obtained, two of which were new to the survey. The population on Eilean Hoan was estimated as 31 AOSs (Table I).

Priest Island

Colonies were mostly small and widely scattered, being found primarily in peat habitats. A total of 1637 responses were recorded from 234 colonies. Of these colonies, 83% produced less than ten responses (Table II). In addition to AOSs found by the playback method, 25 pairs were found breeding in open sites within a cave and these were counted directly. This was because the response probabilities of birds in the cave was very low (0.07 on one visit, 0.31 on another). The overall population for Priest Island was estimated as 2235 AOSs (Table I).

DISCUSSION

Population Status in north-west Scotland

This survey represents the first systematic and repeatable census of these north-west Scottish islands. The distribution maps in Lloyd *et al.* (1991) lists the status of Storm Petrels on Priest Island and Eilean nan Ron as "present; in past believed < 1000 pairs". An estimate for Priest Island of 10,000 pairs was made from trapping probabilities in mist nets compared to those recorded for Skokholm (Dennis 1976). For Priest Island the results of this survey suggest that the status of Storm Petrels is more than double the maximum estimate in Lloyd *et al.* (1991) but considerably less than the estimate in Dennis (1976). On Eilean nan Ron the population from this census is less than 1000 AOSs as suggested in Lloyd *et al.* (1991). Previous estimates of Storm Petrel numbers on these islands are guesses and are of little use for examination of population trends.

There are no previous estimates for Storm Petrel status on the other islands surveyed. This survey has provided proof of breeding on Eilean Iosal and suggested that breeding probably occurs on the Rabbit Islands. Other islands in the north-west Scotland could also be breeding areas for Storm Petrels but these were not censused during this survey. In Sutherland they have been recorded as present on Meall Mor in 1986 (Lloyd *et al.* 1991) and breeding was suspected at Faraid Head between 1968 and 1972 (Cramp *et al.* 1974).

In the Summer Isles off Wester Ross (which includes Priest Island) birds were recorded as present on Bottle Island and Eilean Dubh in 1986 (Lloyd *et al.* 1991), and birds were seen in burrows on these islands as well as Carn Deas and Carn Iar in 1976 and 1977 (pers obs).

Evaluation of playback as a census technique

The use of playback during the day is an effective method of finding and censusing Storm Petrel colonies. However, variations in nest site attendance and response probabilities makes the estimation of the breeding population for an island difficult to ascertain. Several factors are known to affect nest attendance patterns and the response probabilities of petrels.

The probability that a nest site contains an adult bird changes with the stage of the breeding season. Occupancy of the burrow is highest (98%) during the 40 day incubation period and this is the best time to conduct survey work. Diurnal occupation of the burrow is much more erratic during the pre-laying period and once the chick is over 7 days old (Davis 1957, Scott 1970). However, the low degree of synchrony in laying within a colony (Scott 1970) could result in some nest sites containing unattended chicks before others have laid. Knowledge of the timing of the breeding season on the island being censused is therefore essential.

Storm Petrels sometimes leave eggs unattended for one to several days and these sites would be missed during playback census. On Skokholm 2% of eggs were unattended in any one day (Davis 1957) and on Mousa 4.4% of observed changeovers resulted in eggs being temporarily neglected (Bolton 1996). Egg neglect in Storm Petrels appears to be rare compared to other procellariiformes (Bolton 1996) and so is unlikely to result in a serious underestimate in the number of AOSs present.

It is also possible that breeding attempts will be missed due to failure during the egg stage. On Skokholm, hatching success was 62% to 66% with most failure being due to addling of the eggs (Davis 1957, Scott 1970). In these cases, adults would continue to incubate (Scott 1970) and so birds would still be detected by playback censuses.

The most important factor affecting the response probability is the sex of the bird in the nest site. Males always respond to playback of purr calls while only 46% females do so (James 1984). No significant diurnal variation in response probability was found within days on Mousa (Ratcliffe *et al.* 1996) and Vaughan and Gibbons (1995) found little variation between successive days. A small number of repeat tests on Priest Island and Eilean Hoan suggested some diurnal and daily variation but there is insufficient data to allow statistical analysis of the trends. A decline in the probability of a bird responding as the breeding season progresses has been found in Leach's Petrels in Shetland (Ellis *et al.* in prep) and this could also affect responses of Storm Petrels.

Further research into variation of response probability in relation to nesting habitat, geographic location, weather, volume and duration of the playback and the distance of the playback from the nest site is needed.

Inclusion of non-breeders in the census

Most procellariiformes defer breeding for several years after fledging (Warham 1990) and non-breeding birds can represent a large proportion of the whole population. Storm Petrels probably first breed at 4-5 years old (Scott 1970). Scott (1970) identified two types of non-breeding Storm Petrels. Wandering non-breeders fly around the colony at night in large numbers and probably never alight (Scott 1970). Non-breeders occupying a burrow hold temporary territories in

potential nest sites, especially in the year before first breeding (Scott 1970). Including the latter type of non-breeders in surveys of breeding populations would lead to overestimates of population size.

A low diurnal site occupation would be expected for non-breeding Storm Petrels due to their activity over the colony being restricted to the hours of darkness (Scott 1970). Any non-breeder occupying a nest site by day would be confined there until the following night and during this period would lose 6% of their total body weight (Bolton 1996). Diurnal attendance would confer little benefit to the bird as it would not have to defend the site until the next evening when other non-breeders returned.

Data from Skokholm support this hypothesis. Non-breeding Storm Petrels visit burrows at night frequently (Scott 1970) and comprised 30% of all occupied sites found. However, diurnal occupation of these sites was infrequent, with each being used for only 3 or 4 days in an entire breeding season. This means that only about 3% of birds in burrows during any one day would be non-breeders. It is thus probable that the majority of birds responding to playback during a single day are breeding birds and non-breeders probably only represent a small proportion of AOSs detected during this census.

Were any colonies missed?

There were 40 sub-colonies on Priest Island where only a single response was obtained. Some of these would be sites where there was only one AOS present but others may have contained more AOSs that did not respond. There will have been instances where one or more birds were present but none of them responded, resulting in some small sub-colonies being undetected. It is highly unlikely that any larger colonies (over 10 pairs) were not detected.

SUMMARY

From mid-July to early August 1995 a survey of Storm Petrels was undertaken on Eilean nan Ron, Eilean Iosal, Rabbit Islands, Neave Island and Eilean Hoan, Sutherland and on Priest Island, Wester Ross. Playback of the male purr call was used to elicit responses from birds occupying burrows to locate and census colonies. Many of the sub-colonies consisted of small groups of birds, with 80% of the sub-colonies on Priest Island eliciting less than ten responses. The number of apparently occupied sites estimated for each island were: Eilean nan Ron 166, Eilean Iosal 57, Rabbit Islands 4, Eilean Hoan 31 and Priest Island 2235. No responses were recorded on Neave Island. Factors affecting response probabilities and diurnal nest site attendance are discussed. It is concluded that the daytime playback technique is presently the most appropriate method for both finding and censusing Storm Petrel colonies. It is essential that further research is conducted concerning the factors affecting nest attendance and response probabilities so that assumptions made during this survey can be validated.

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A. R. Mainwood, 13 Ben Bhraggie Drive, Golspie, Sutherland, KW10 6SX, UK.

N. Ratcliffe, The Royal Society for the Protection of Birds, The Lodge, Sandy, Beds., SG19 2DL, UK.

S. Murray, Craigie Dhu, Cardney, Dunkeld, Perthshire, PH8 0EY, UK.

G. P. Mudge, Scottish Natural Heritage, 2 Anderson Place Edinburgh, UK.

Ringling recoveries and colony attendance of Isle of May Guillemots

M.P. Harris, S.R. Baillie & C. Dudley

INTRODUCTION

In most parts of their range Common Guillemots *Uria aalge* only visit land just before and during the breeding season (Tuck 1961). The population breeding in east Britain is, therefore, unusual in that some birds attend colonies during most months of the year (Taylor & Reid 1981). The annual cycle of Guillemots on the Isle of May, Firth of Forth, east Scotland is well documented. The earliest eggs are laid in mid-April with the peak of laying in the first two weeks of May (Harris & Wanless 1988). Most successful males take their chick, still only partly grown and flightless, to sea during June or early July, and females remain at the colony with the non- and failed breeders until mid-July. The latest chicks depart during the second week of August.

The usual age at first breeding of Isle of May Guillemots is six years (Harris *et al.* 1994) but birds visit the colony from their second year of life. Two year-old birds arrive in mid-June, third year individuals appear in early June, and most four year-olds in mid- to late-May. Older individuals spend more time at the colony than do younger individuals and all age-groups leave more-or-less synchronously in mid-July (Halley *et al.* 1995). The Guillemot chick is fed at sea until it becomes independent 70-85 days after leaving the colony (Varoujean *et al.* 1977).

The main moult of the year for adults and immatures occurs soon after they leave the colony. During this moult individuals are flightless for 45-50 days (Birkhead & Taylor 1977). Some adults start to return to the Isle of May soon after they can fly again from early October, and, in most years, the majority visit their nest-sites before the end of the month (Harris & Wanless 1990). Few nonbreeders return in the autumn. During the winter, birds are present at the colony for an hour or two, just after dawn, on only some days and attendance varies greatly in frequency and numbers, both with date (visits being less frequent in mid-winter) and year (Harris & Wanless 1984, 1989). By early March birds are present on their breeding ledges for many hours, on many days.

Small numbers of Guillemots have been ringed at the colony on the Isle of May since the 1930s by the Isle of May Bird Observatory, but only in recent years have sufficient recoveries accumulated for an assessment to be made of the pattern of recoveries. This short paper draws on, and updates, maps from Baillie *et al.* (1994) and attempts to interpret the patterns of recoveries against what is known of colony attendance during the year.

METHODS

The analysis was based on all recoveries reported between January 1970 and August 1995 but the bulk of recoveries refer to the period 1983-95. Most recoveries were of birds ringed as chicks so the age at recovery was known precisely. Recoveries of birds ringed as "adults" were combined with those of birds ringed as chicks, and recovered when older than three years, as preliminary inspection of the recovery distributions for these two sub-groups from many colonies indicated that they were extremely similar (Baillie *et al.* 1994). Most birds ringed as "adults" are likely to have been breeders when they were caught. Recovery years used to assign recoveries to age categories started on 1 July.

As Guillemots disperse widely in their first year and return in increasing numbers to their breeding colonies as they get older (Birkhead and Hudson 1977), the following categories of age

classes, based on attendance of known age birds (above) were used for this analysis: first year (no birds return to colony), second and third years (attend for short periods), and adults (breeders and non-breeders over three years old).

The four periods of recovery used in this analysis were April-June (main breeding season), July-September (moult), October-December (early winter) and January-March (late winter). Recoveries of birds that were sick or rehabilitated when ringed were excluded from the analysis, as were recoveries where only the ring was found. Records where the finding date was not known to within 30 days or where the finding co-ordinates could not be determined to within 30 minutes were also omitted. However, records where the date was taken from the postmark on the letter were used. Finding details and even finding locations of some recoveries were missing, hence sample sizes vary slightly between analyses. The bulk of recoveries were coastal and some recovery locations on the maps are offset slightly in the interests of clarity.

RESULTS

Methods of recovery

The bulk (55%) of the 275 recoveries where details of the circumstances of finding were reported were 'found dead', with 22% being found oiled, 20% caught in fishing nets and 3% shot (Table I). There was a significant difference between the manner of recovery of the different ages ($\chi^2 = 36.5$, $P < 0.01$) with all the shot birds and 40 (71%) of those caught in nets being first-year individuals. A tendency for young Guillemots to be reported shot or caught in nets is well known (Birkhead 1974, Heubeck *et al.* 1991).

TABLE I. METHODS OF RECOVERY OF GUILLEMOTS RINGED ON THE ISLE OF MAY IN RELATION TO THEIR AGE AT RECOVERY. PERCENTAGES OF TOTALS ARE GIVEN IN BRACKETS.

Age at recovery	Dead	Oiled	Reported as		Total
			Shot	Caught in nets	
1st year	97	17	9	40	163 (59)
2nd and 3rd year	23	17	0	9	49 (18)
Older	30	26	0	7	63 (23)
Total	150 (55)	60 (22)	9 (3)	56 (20)	275

TABLE II. NUMBERS OF ISLE OF MAY RINGED GUILLEMOTS RECOVERED IN DIFFERENT TIME PERIODS. PERCENTAGES OF COLUMN TOTALS ARE GIVEN IN BRACKETS.

Time period	Age			Total
	First year	2nd and 3rd year	Adult	
July-Sept	6 (3)	4 (8)	3 (5)	13 (5)
Oct-Dec	61 (36)	9 (17)	8 (13)	78 (28)
Jan-March	84 (50)	33 (62)	41 (68)	158 (56)
Apr-June	18 (11)	7 (13)	8 (13)	33 (12)
Total	169	53	60	282

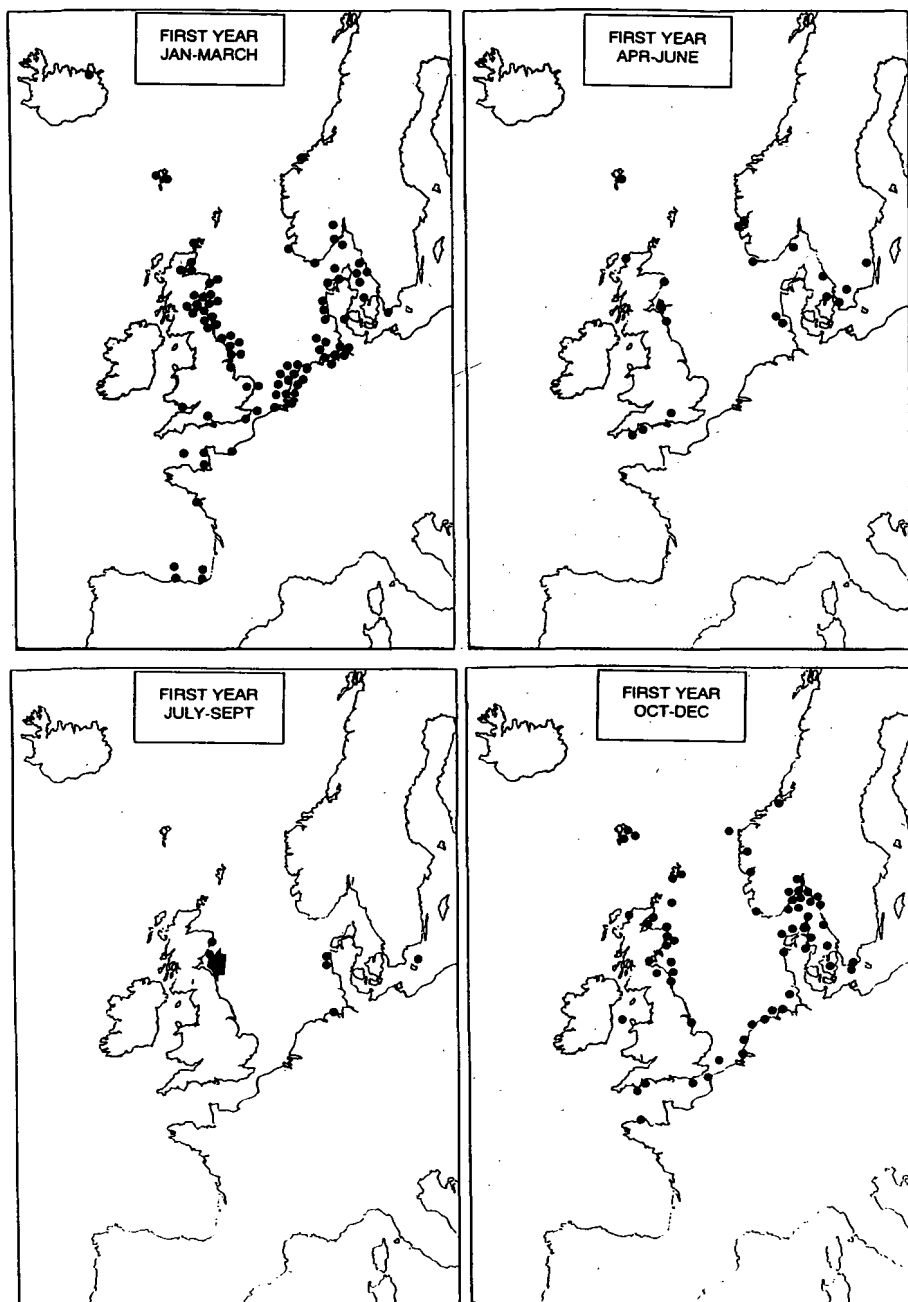


Figure 1. Recoveries of Guillemots ringed on the Isle of May (indicated by arrow) and recovered in their first year of life.

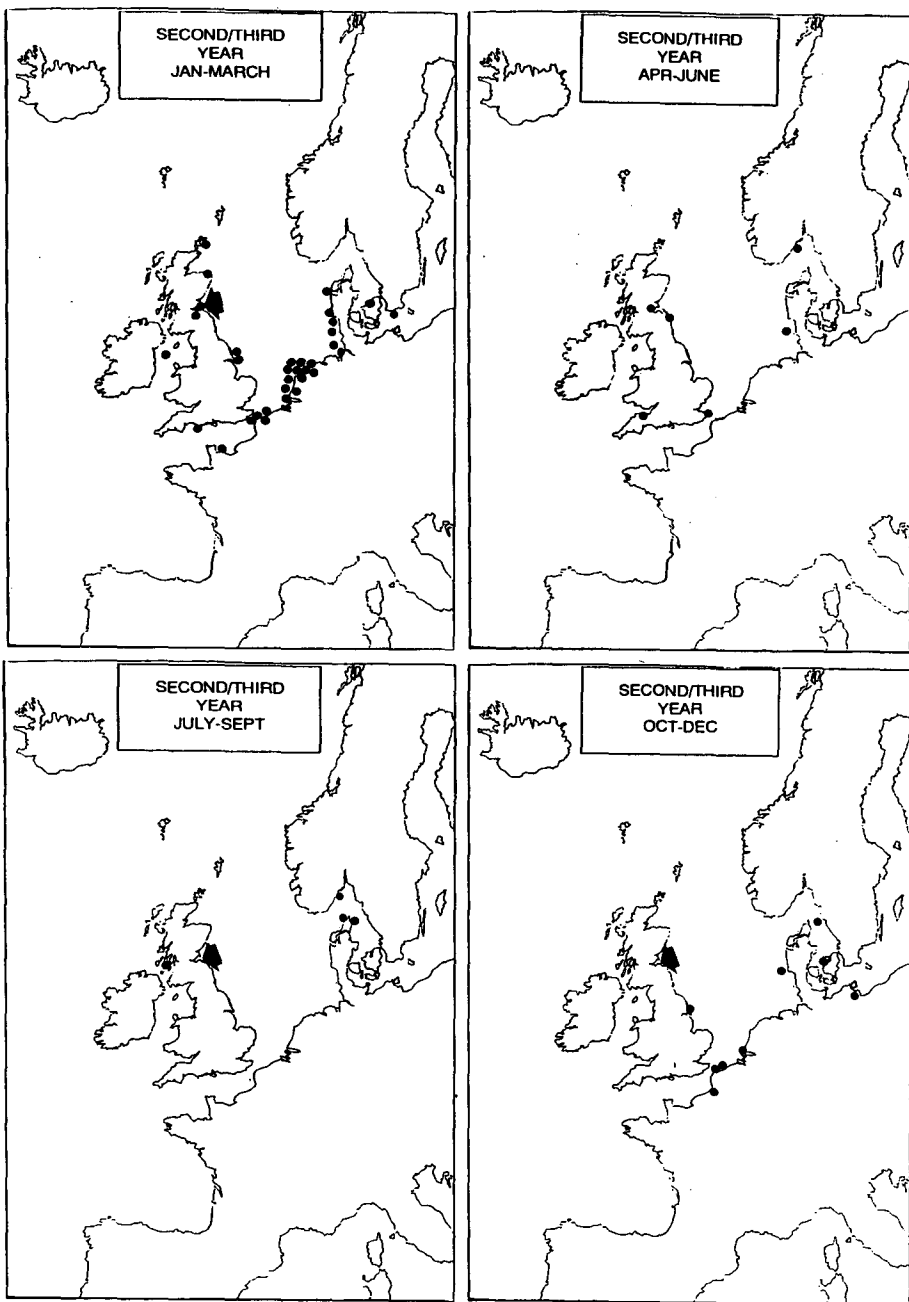


Figure 2. Recoveries of Guillemots ringed on the Isle of May (indicated by arrow) and recovered in their second or third years of life.

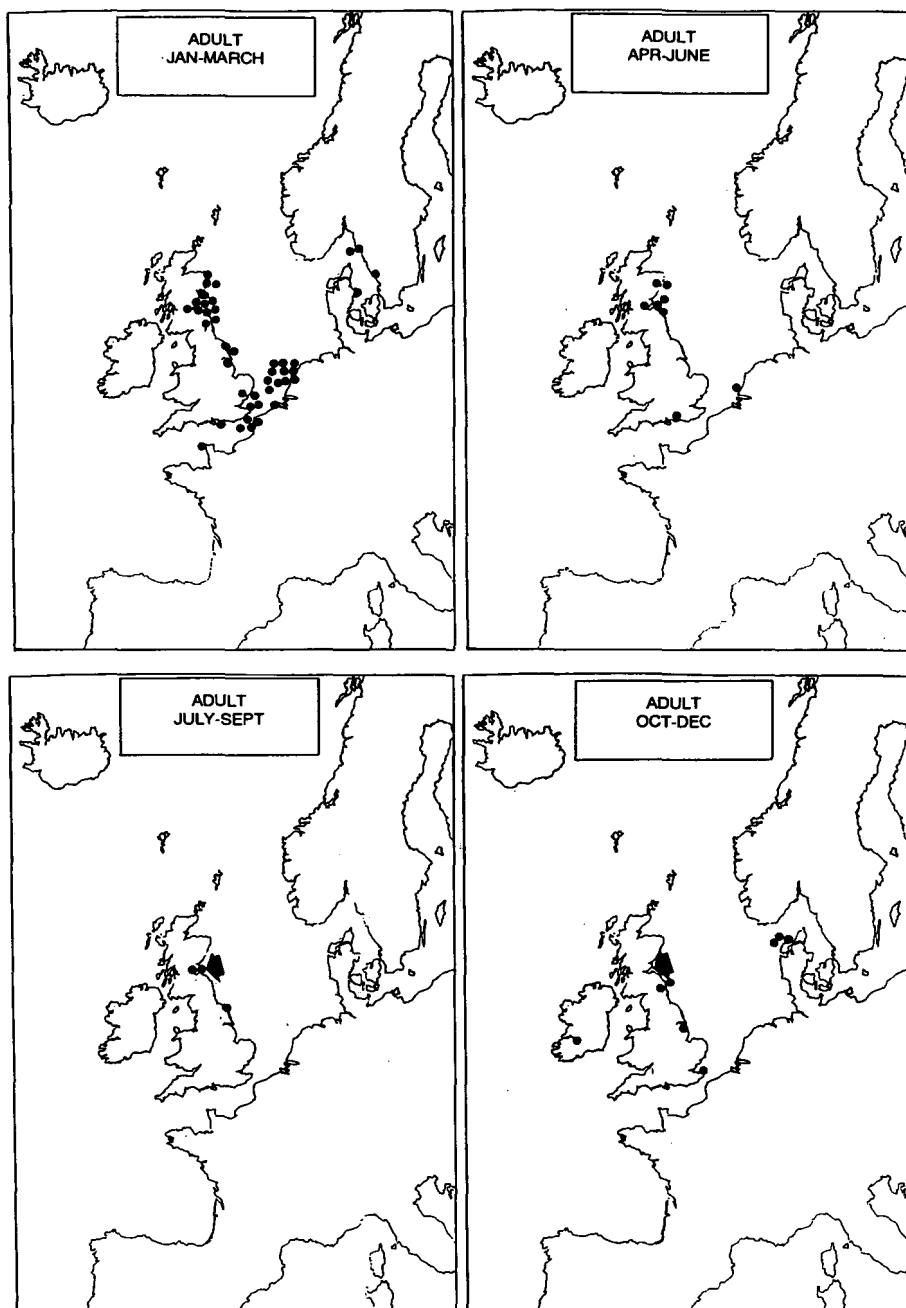


Figure 3. Recoveries of Guillemots ringed on the Isle of May (indicated by arrow) in their fourth or subsequent years of life.

Timing of recoveries

Of the 282 recoveries, 169 (60%) were of birds in their first year of life, 53 (19%) were in their second and third years, and 60 (21%) were adult (Table II). The bulk of the recoveries (56%) occurred between January and March with only a minority (5%) between July and September. This pattern occurred in all three age groups (all $\chi^2_1 > 16.0$, $P < 0.01$) suggesting that most mortality occurs during the late winter.

Pattern of recoveries

The recovery locations by age-group and season are shown in Figures 1-3. Four of the six recoveries of chicks reported soon after fledging were well dispersed away from the ringing area and included a single record from the Baltic. By the end of the calendar year, young were reported around the fringes of the North Sea with a concentration in the Kattegat and Skagerrak. A single bird was recovered in the Irish Sea and three were shot off the Faeroe Islands. Between January and March, young were reported from Iceland, the Faeroe Islands and the Bay of Biscay with concentrations on the south-east coast of the North Sea, between west Germany and Holland, and in east Britain. Fifteen of 26 recoveries in north-east England and east Scotland came from a wreck in February 1994, after a prolonged spell of easterly winds which may have driven ashore birds from a wide area of the North Sea (Harris & Wanless 1996). The relatively few records in the summer were again well dispersed, with no suggestion of a return to east Scotland.

The patterns of recoveries in the second and third years of life and of adults, were similar to those of younger birds except that many fewer recoveries came from the Kattegat and Skagerrak. The concentration in Holland persisted. No adults were reported from east Scotland between October and early February even though the bulk of the population should have been visiting the colonies during this time.

Seven birds which were known to have bred on the Isle of May were recovered in February, March or early April, i.e. during the period when they should have been attending colonies regularly. The median recovery distance from the Isle of May of these birds was 148 km with the range being 12-762 km.

DISCUSSION

The main mortality for all ages of Isle of May Guillemots appears to have occurred between January and March. There were remarkably few recoveries between July and September, despite the fact that virtually all chicks, immatures and adults should have been flightless and (presumably) at risk from severe weather and/or other adverse conditions at this time (Halley 1992). In contrast, Birkhead (1974) recorded a peak of mortality in late summer and early winter among British east coast Guillemots in their first year of life recovered up to 1972. These included 12 recoveries of Isle of May-ringed chicks, 11 of the recoveries were of birds shot in Norway between 1936 and 1962 and most (nine) were between October and December. It is difficult to make a meaningful comparison but there does seem to have been a change in the timing of recovery, and by inference, mortality in Guillemots over the last twenty years.

Mead (1974) in his analysis of the recoveries of Guillemots ringed in north and east Britain and reported prior to early 1972, found that most came from within the North Sea with concentrations in southern Norway, the Skagerrak and Kattegat. Although he noted that a few first year birds were recovered in the southern North Sea between Denmark and France, most recoveries of birds of that age were from south-west Norway. Although in the 1970s, 1980s and 1990s many birds ringed at colonies in Shetland, east Sutherland, Caithness and Ross-shire were recovered in Norway (Heubeck *et al.* 1991, Baillie *et al.* 1994), few Isle of May birds appear to have gone there. Rather Isle of May birds moved further south. Mead (1974) had no reports of adult Guillemots recovered between Denmark and France but recoveries subsequently suggest that a large proportion of the Isle of May adults visit this area between January and March. There are

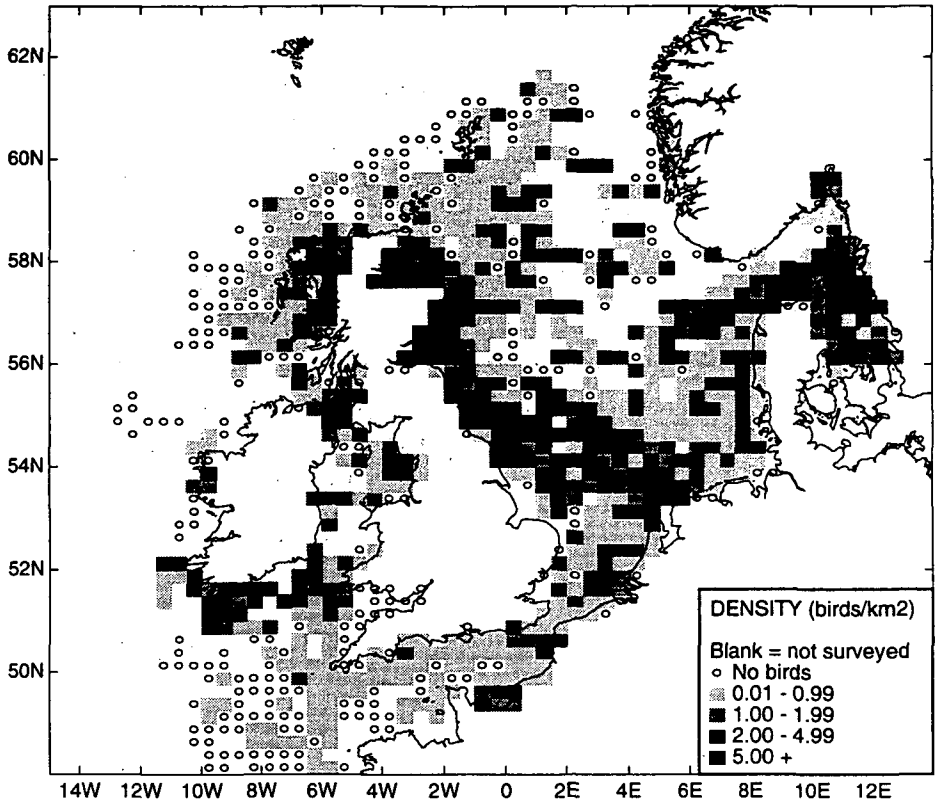


Figure 4. Distribution of Guillemots in the North Sea and adjacent seas in October-December. Data from European Seabirds at Sea Database. Details of methodology can be found in Stone *et al.* (1995).

additional records of birds being oiled, cleaned, ringed and rehabilitated in Holland (2) and Germany (1) and later being found breeding or site-holding on the Isle of May (pers. obs.).

The wintering area in the south-east North Sea is about 550-650 km from the Isle of May. Guillemots fly at about 70 km per hour (Pennycuik 1987) and, as individual Guillemots are often away from the colony for periods of 3-5 days during the winter and prior to laying (pers. obs.), the Isle of May adults could well be using the southern North Sea as a major feeding area when attending the colony. There is nothing in the dispersion of recoveries of older birds to indicate that they were regularly attending colonies during the autumn and early winter.

The pattern of recoveries during the winter is similar to the distribution of Guillemots in the North Sea as shown by ship- and air-based surveys (Figs. 4 and 5). The southern North Sea has been an important wintering area for Guillemots during most of the 1980s and early 1990s but seawatching data and information on strandings, suggest that the area increased in importance in the early 1980s after a period of 10 years with comparatively few being recorded (Camphuysen & Leopold 1994). The ringing recoveries also indicate a marked change in the dispersal of Guillemots during the winter during the last 20 years.

It is known from many years work on the Isle of May that adults spend a considerable amount

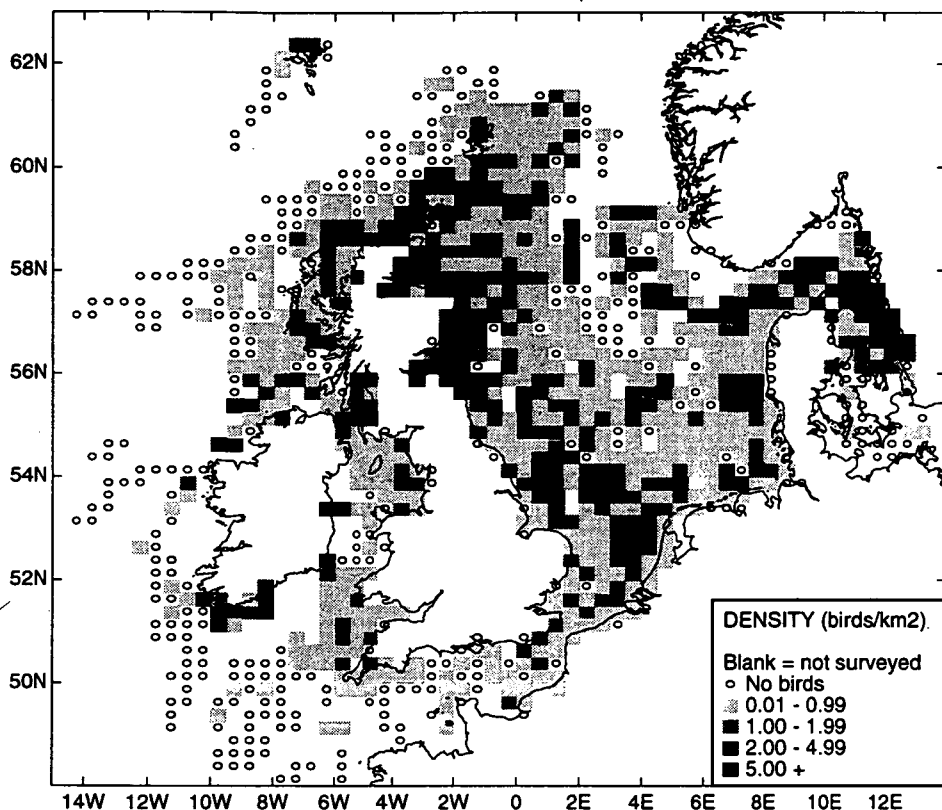


Figure 5. Distribution of Guillemots in the North Sea and adjacent seas in January-March. Data from European Seabirds at Sea Database.

of time at the colonies during the early and late winter when most of the recoveries are recorded. However, despite the Isle of May being near to one of the main centres of human population in Scotland, so that many beaches are regularly searched for dead birds, few ringed birds are reported. The conclusion must be that ringed birds die away from the colony. This agrees with observations that when conditions become unfavourable during the winter, adults stop visiting the colonies (Harris & Wanless 1984). There is nothing in the dispersion of recoveries of older Guillemots which would indicate that they were regularly attending colonies during the autumn and winter, even in years when direct observations confirmed that they were.

ACKNOWLEDGEMENTS

Our thanks are due to the many people from the Isle of May Bird Observatory who ringed Guillemots and to those who later reported them. The maps of the distribution of Guillemots at sea came from the European Seabirds at Sea Database, courtesy of the Joint Nature Conservation Committee. Part of the analysis was undertaken under a contract from Scottish Natural Heritage. M. Heubeck and J. B. Reid improved the manuscript with their criticisms. The rings placed on Guillemots are currently paid for by the Joint Nature Conservation Committee's Seabird Monitoring Programme.

SUMMARY

Most recoveries of Guillemots ringed on the Isle of May, south-east Scotland were reported between January and March. The main causes of death of birds in their first year of life were drowning in fishing nets or being shot by hunters. Most recoveries came from the shores of the North Sea with marked concentrations in the Kattegat and Skagerrak and from west Germany to Holland. There were few differences in the distribution of recoveries with age. The south-east North Sea is an important wintering area for Isle of May Guillemots. The dispersion of recoveries gives little indication of the winter colony attendance at this colony.

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M.P. Harris, Institute of Terrestrial Ecology, Hill of Brathens, Banchory, Kincardineshire AB31 4BY, UK.

S.R. Baillie, and C. Dudley, British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU, UK.

An estimate of the numbers of Storm Petrels *Hydrobates pelagicus* breeding on Aukerry, Orkney

David Wood

INTRODUCTION

Petrels and shearwaters remain poorly censused in the UK. Colonies are often located on difficult-to-access slopes or boulder beaches on remote offshore islands, and the birds are active above ground only by night. These factors pose considerable logistical and safety challenges to any would-be surveyor.

Some difficulties can potentially be eased by using vocal responses of burrow-occupying birds to the daytime playback of an appropriate call (James & Robertson 1985). Work carried out on Storm Petrels *Hydrobates pelagicus* on Mousa, Shetland between 1991 and 1994 indicates that the maximum daytime response to playback occurs between 7 July and 7 August, the period when most Storm Petrels are incubating, and that response rates are constant throughout the day (D. Suddaby pers. comm.). Playbacks made during daylight hours minimise the risk of detecting non-breeding Storm Petrels, as few non-breeders occupy sites by day (Scott 1970). The response rates of male and female Storm Petrels to the playback of male purr-calls is known for a single colony at Skomer, Wales (James 1984). This response behaviour was used as the basis of a method to census the Storm Petrels breeding on Aukerry, Orkney.

My study aimed: (i) to establish the distribution and density of potential nesting burrows across the island; (ii) to map the main concentrations of boulder beach and ruins habitat occupied by nesting petrels; (iii) to estimate the occupancy of sites in both habitats, and hence produce a population estimate for the whole island.

METHODS

Aukerry is a small offshore island (approximately 1.5km x 1km) lying 5km south of Stronsay in the Orkney group at 59°2'N, 2°34'W (Fig. 1). The island is low-lying, rising to only 18m in the west. The dominant vegetation types are heather *Calluna vulgaris* heath and acidic grassland, with smaller areas of tufted hair-grass *Deschampsia cespitosa* tussocks on parts of the east and west coasts. All vegetation types are closely grazed by sheep. Most of the coast is rocky, with some boulder and shingle beaches and low cliffs. Aukerry has long been known to hold an important colony of Storm Petrels (Booth *et al.* 1984). The birds nest in old rabbit burrows across the island, among large slab-like boulders around the coast, and in the collapsed ruins of old, small drystone buildings. The other burrow-nesting seabirds present, Puffin *Fratercula arctica* and Black Guillemot *Cephus grylle*, occur only in small numbers and mainly occupy cliff top burrow and cliff crevice sites away from petrel nesting areas. Rabbits became extinct in the 1950s and no other burrowing mammals are present.

The census was carried out from 26 to 28 July 1995 by a single fieldworker. Birds occupying burrows were treated separately from birds nesting among boulder beach and ruins.

Burrows

To ensure that all areas were searched for burrows, parallel east-west lines at 50m spacing were drawn on a map of the island. In the field, the start of each line was identified with reference to coastal features, and a search made along the line with the aid of a compass. The areas containing burrows were mapped and the total burrowed area calculated. All burrows located were assumed to be potential petrel nesting sites.

Within the burrowed areas on West Hill and to the north of the lighthouse, three rectangular areas totalling 12500m² were defined with bamboo poles, and divided into 10m x 10m squares. Fifty of these squares were randomly selected, and the southwest corner of each used as the centre of a 60m² circular quadrat which was carefully searched for burrow entrances. The total area searched amounted to 1.7% of the total burrowed area. Burrow entrances were obvious among the heavily grazed vegetation and it was assumed that all entrances present were located.

To assess burrow occupancy, a recording of Storm Petrel purr-call was played at maximum volume at each burrow entrance between 0900 and 1800h. A small portable tape player (Grundig CR105) with a nominal output of 1.5W was used, and the recording was obtained on Skokholm on 16 May 1992. Preliminary playbacks before the survey began, indicated that some birds provided only a very quiet response; therefore, after 15s of playback, the tape was switched off and the observer listened carefully for 10s by placing an ear directly at the burrow entrance. Responses were categorised as none, purr-call, flight-call or a response including both of these calls, with reference to the call types described in Cramp and Simmons (1977). When two or more calls were heard simultaneously from a single burrow, an attempt was made to distinguish the total number of birds calling. It was assumed that all responses that included a purr-call or flight-call were from breeding birds, and that one calling bird represented one breeding pair. Chick calls were noted separately. Care was taken to ensure that the same response was not recorded twice from different entrances.

Boulder beach and ruins

All apparently suitable areas of ruin and boulder beach around the coast of the island were noted on a map. Habitat holding petrels was confirmed by making a daytime playback of purr-call, at ground level and at maximum volume, at 2m intervals in all areas of apparently suitable habitat. These areas were mapped separately and the total area of occupied habitat calculated.

Within the occupied areas, the density of birds was assessed by placing 15 2m x 2m quadrats over the boulders and making a playback of purr-call, at maximum volume, at the centre of each. The boulders shifted easily underfoot, so instead of the preferred random selection, quadrats were placed in locations that could be reached with minimum disturbance to the nesting habitat. The number and type of responses in each quadrat was noted as for burrow-nesting birds. All playbacks in the boulder beach and ruins were made between 0900 and 1300h.

The weather during playbacks in all habitats was sunny, with wind conditions between calm and Force 2. It was assumed that all responses made were heard, and correctly classified, by the observer.

RESULTS

Burrows

Burrows were estimated to occupy 179900m² of the island (to the nearest 100m²), with most present on well-drained level or slightly sloping ground (Fig. 1). Wet, low-lying areas had very few burrows.

Over a third of the 60m² quadrats contained no burrows and the maximum number of burrows per quadrat was nine (Table I). Forty responses were obtained from 104 burrows, and the mean number of responses obtained per quadrat (for all call types) was $0.80 \pm \text{s.d. } 1.36$ (95% confidence limits 0.43 - 1.17 responses per quadrat) (Table II). The whole-island estimate for the number of burrow-occupying petrels that would have responded to playback was therefore 2399.

James (1984) showed that, for 37 male and 28 female Storm Petrels on Skomer, all males responded to the playback of a purr-call, half with the purr-call and half with the flight-call. Only 45% of females responded to a purr-call, and then only with the flight call. If approximately equal numbers of males and females were incubating (Davis 1957), 35% of all responses would have been purr-calls. By contrast, 65% of responses in the present study included a purr call (Table III).

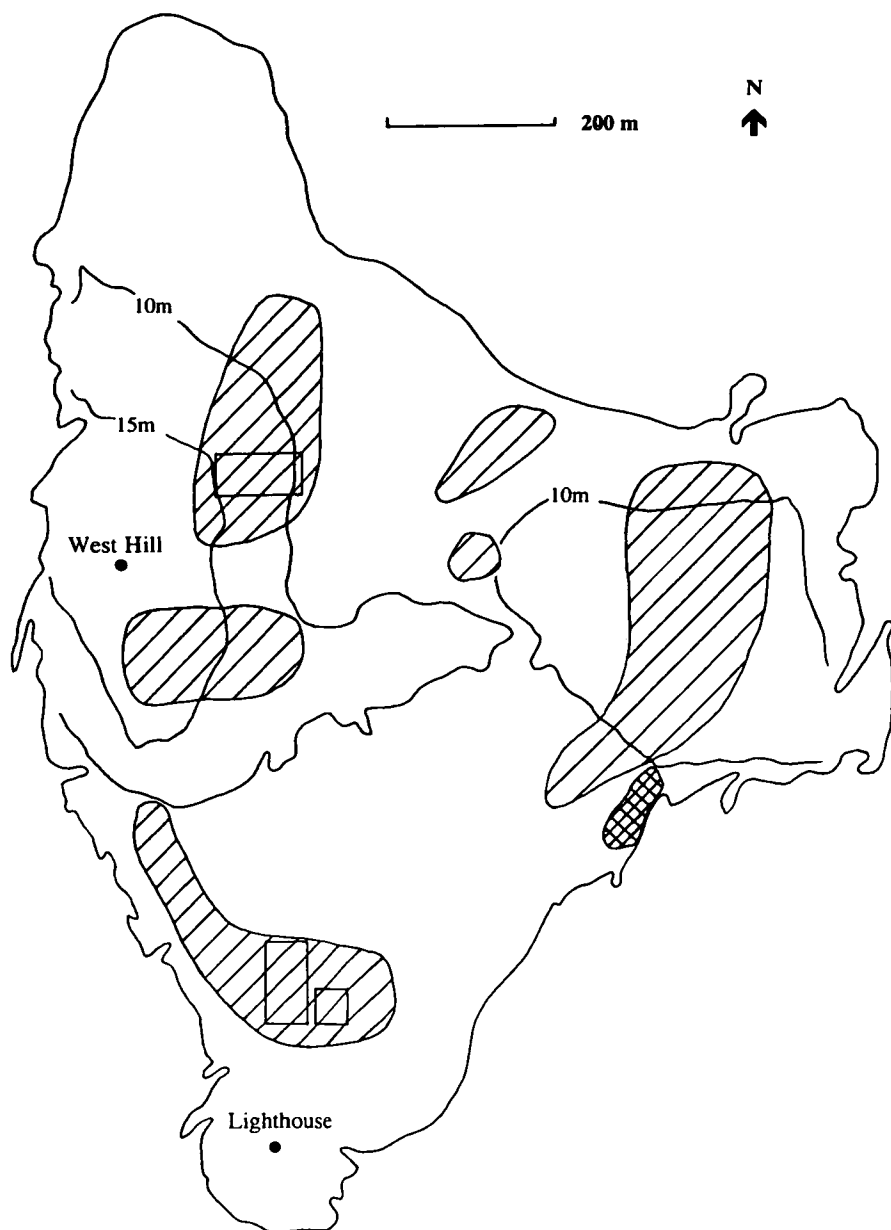


Figure 1. The distribution of habitats occupied by nesting Storm Petrels on Auskerry. Hatched: burrows; cross-hatched: boulder beach and ruins. The rectangles indicate the locations of plots used to determine burrow density and occupation.

This is approximately consistent with all males responding with a call that included some purr element, and 45% of females responding with flight-calls. For the purposes of this study, this modified response rate was assumed to apply across the burrows habitat.

Number of males present = $(4 + 22) = 26$

Number of females present = $14 \times (100/45) = 31$

Total number of adult birds occupying burrows by day = $(26 + 31) = 57$

Ratio of adult birds occupying burrows by day to total number of responses = $(57/40) = 1.43$

The corrected estimate for the number of petrels occupying burrows by day was therefore 3431 birds with 95% confidence limits of 1843 and 5016.

TABLE I. THE NUMBER OF BURROWS IN 50 60 m² QUADRATS

<i>Number of burrows per 60 m² quadrat</i>	<i>Frequency</i>
0	19
1	7
2	7
3	5
4	4
5	2
6	4
7	0
8	0
9	2

TABLE II. THE NUMBER OF RESPONSES TO PLAYBACK FOR 104 BURROWS

<i>Number of responses (all types) per 60m² quadrat</i>	<i>Frequency</i>
0	30
1	9
2	8
3	1
4	0
5	0
6	2

TABLE III. THE TYPE OF RESPONSES TO PLAYBACK FOR 104 BURROWS

<i>Number of birds responding per burrow</i>	<i>Frequency</i>	<i>Number of responses obtained of type:</i>		
		<i>purr only</i>	<i>flight only</i>	<i>purr + flight</i>
0	71	-	-	-
1	27	1	8	18
2	5	1	6	3
3	1	2	0	1
TOTALS	104	4	14	22

A single chick call was heard from one burrow. This burrow also gave a purr+flight response, and it was assumed that this represented an adult brooding its own young chick.

Boulder beach and ruins

The locations of occupied habitat, as indicated by responses to playback of purr-call, are indicated on Fig. 1. Areas of apparently suitable boulder beach on the east and south coasts of the island were unoccupied, with petrels present only in a few dense pockets under flat slabs and in ruins on the south coast. The estimated area occupied was 179m² and Table IV shows the number and type of responses to playback of purr-call.

The mean number of birds responding per 2m x 2m quadrat was $2.93 \pm \text{s.d. } 1.49$ (95% confidence limits 2.10 - 3.76 responses per quadrat). The minimum estimate for the number of birds occupying this habitat was therefore 131 birds.

The ratio of the response types coincides with those obtained by James (1984). Therefore:

Number of males responding with call including a purr element = 15

Total number of males present = $15 \times (100/50) = 30$

By subtraction, number of females responding = $(44-30) = 14$

Number of females present = $14 \times (100/45) = 31$

Corrected estimate of the number of petrels present in 15 quadrats = $(30 + 31) = 61$

Corrected estimate of the number of petrels present per quadrat = $(61/15) = 4.07$

The corrected estimate for the number of petrels in boulder beach and ruin habitat by day was therefore 182 birds with 95% confidence limits of 131 and 234 birds.

Combining the estimates for the burrows and boulder beach/ruin habitats, the number of Storm Petrels occupying nesting sites by day was estimated to be $(3431 + 182) = 3613$ birds.

TABLE IV. THE NUMBER AND TYPE OF RESPONSES TO PLAYBACK FOR QUADRATS ON BOULDER BEACH AND RUIN HABITAT

Quadrat	Number of responses obtained of type:			Total number of responses obtained
	purr only	flight only	purr + flight	
1	0	2	2	4
2	0	2	2	4
3	0	2	1	3
4	0	2	2	4
5	0	2	1	3
6	0	1	0	1
7	0	0	1	1
8	0	0	0	0
9	0	3	1	4
10	0	2	2	4
11	0	1	0	1
12	0	3	0	3
13	1	2	0	3
14	1	3	0	4
15	1	4	0	5
TOTALS	3	29	12	44

DISCUSSION

Utilisation of the two habitat types

Despite the high density of petrels present in occupied boulder beach and ruins habitat (approximately one bird per m²), large areas of seemingly similar boulder beach were unoccupied. Similarly, most burrow entrances that were tested with the tape did not provide a response. The reasons underlying the pattern of habitat occupation are unknown.

The precision of the population estimate

The estimate of the mean burrow density has large confidence limits, which could have been reduced by increasing the number of number of quadrats, but time did not allow this. Burrow density in all occupied areas was judged to be similar, so it is unlikely that a stratified sampling approach would have given a substantial improvement. The relative lack of precision means that only a substantial change in breeding numbers would be detected by any resurvey.

The accuracy of the population estimate

I believe that all burrows present in the quadrats were located, and because of exceptionally calm weather conditions, that all calls made in response to playback were detected. I also considered that no petrels were recorded twice through different entrances to the same burrow; entrances were generally widely spaced. However, a number of other sources of bias may have affected the accuracy of this population estimate. Firstly, burrow contents were judged entirely by the frequency and type of response to playback. This places great reliance on the information available on the response types and rates of both sexes, and the resulting correction factors used. In the case of Storm Petrel, these were derived from responses to playback of 82 birds on Skomer (James 1984), but their validity for other colonies is unknown. The high proportion of purr-calls obtained from burrows on Aukerry (over 70%) contrasts with a lower proportion of purrs obtained from Aukerry boulder beach/ruin habitat (present study), Skomer (James 1984) and Priest Island in Wester Ross, Scotland (Mainwood *et al.* 1997). The tape player used on Aukerry had a relatively high audio output and, for burrow nesting petrels, the playback was made directly at each burrow entrance. This combination could have subjected incubating birds to much stronger vocal stimulation than petrels nesting in boulder beach and ruin habitat, where playbacks were made at the centre of 2m x 2m squares, or in peat burrows on Priest Island, where a less powerful player was used (Table V). This aspect of the methodology requires further investigation, perhaps using artificial nesting chambers in which the sound level of playback in the nesting chamber could be precisely controlled. It will prove difficult to standardise completely the intensity of stimulus provided to incubating birds in natural nest sites, because differences in nesting habitat within and between islands will alter the audibility of the playback to incubating birds in ways that would prove difficult to quantify or control (for example, length of nesting burrow or thickness of wall). A further explanation for the between-colony variation could be that the relative contribution of each sex to incubation changes with geographical location or with the phase of incubation.

No correction was made for daytime occupation of sites by non-breeding petrels. The numbers of non-breeders occupying burrows by day is not known exactly, but is probably only a few percent (Scott 1970, Mainwood *et al.* 1997). Nonetheless, the presence of such birds, if they responded to the playbacks, will have resulted in overestimation of the breeding population. In addition, no allowance was possible for breeding attempts in which neither member of the pair occupied the nest site when playback was made. Although the playbacks were timed to coincide with the period when most breeders would be incubating, as judged by work in Shetland (D. Suddaby pers. comm.), Storm Petrels have a protracted laying season, and some pairs may not have laid by the survey date, while others may already have failed. Furthermore, particularly 'early' pairs with unattended chicks would also have gone unrecorded. None of these categories

TABLE V. THE PROPORTION OF PURR CALLS OBTAINED IN RESPONSE TO PLAYBACK IN RELATION TO PLAYBACK POSITION AND PLAYBACK EQUIPMENT USED

<i>Location and habitat</i>	<i>Audio output of player</i>	<i>Position of playback</i>	<i>% of responses that included a purr-call</i>
Auskerry, burrows	1.5W	At individual burrow entrances	65
Auskerry, ruins & boulder beach	1.5W	At centres of 2m x 2m squares	34
Skomer, burrows	Unknown	At individual burrow entrances	35
Priest Island	0.2W	At individual burrow entrances	30

would have been detected by the methodology adopted in this study. Indeed, as most biases would have resulted in under-estimation of the number of breeding birds present, the estimate obtained here should more properly be seen as a *minimum* for Auskerry. It is hoped that methodology for the playback technique will continue to improve and that better correction factors will become available. Future surveys should record full details of all playback methods and responses obtained to aid this development. Notwithstanding present limitations, this was an efficient field technique for the Auskerry colony.

SUMMARY

A survey of Storm Petrels was carried out on Auskerry, Orkney over three days in July 1995. For petrels occupying burrows, burrow distribution was mapped visually and burrow occupancy then assessed by the playback of a male purr-call. The estimate for this habitat was 3431 birds (95% confidence limits 1843 - 5016). For birds nesting in boulder beach and ruins, playback was used both to detect occupied areas and to census the birds present. In this habitat, the estimate was 182 birds with 95% confidence limits of 131 and 234. Playback was an efficient field technique for Storm Petrels on Auskerry but refinement of the methodology is required to improve the interpretation of response rates.

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David Wood, Scottish Natural Heritage, 54-56 Junction Road, Kirkwall, Orkney KW15 1AW, UK

Estimation of digestion and defaecation rates in the Shag *Phalacrocorax aristotelis*

S. Wanless, D. Grémillet, G. M. Hilton and M.P. Harris

INTRODUCTION

During the chick rearing period, adult Shags *Phalacrocorax aristotelis* usually do not return directly to the nest after they have finished foraging but spend time ashore either close to the breeding colony or, less commonly, the feeding area (Wanless *et al.* 1993, Grémillet *et al.* 1996). Digestion rates in piscivorous birds are known to be extremely rapid (e.g. van Dobben 1952, Partridge 1986, Jackson 1992) and Wanless *et al.* (1993) speculated that this delay in returning to the nest enabled the adult to digest part of its own food requirements before returning to the brood. Thus the food still present in the stomach on its arrival at the nest was principally for the young. During studies of feeding performance and digestive efficiencies of Shags we collected some empirical data which support this hypothesis and also provide information on defaecation rates for this species.

METHODS

Work on the feeding performance of Shags was carried out on the Isle of May, south-east Scotland (56°11'N, 02°33'W) between 6 and 24 July 1994. Changes in adult body mass were determined for four pairs of Shags using an automatic nest balance system consisting of two electronic balances, a laptop computer and a car battery (see Grémillet *et al.* 1996, for full details). In brief, the system consisted of a weighing platform (350 x 295 mm) with an accuracy of 5 g (over the mass range 0-30 kg), enclosed in a strong polythene bag and carefully positioned under a Shag's nest. Weighing data were sent to the computer approximately once every second and subsequently analyzed using the programme WAAGE (Jensen Software Systems, Am Schutterrain 31, D-77694 Kehl, Germany).

Over the course of a day, members of a Shag pair typically make alternate feeding trips whilst chick rearing. When a Shag returns, the birds change over and the sitting bird gets off the nest. Such behaviour results in a characteristic step event in the total nest mass which allows the body mass of each adult to be calculated. Trip duration (TB) was defined as the interval between a bird getting off and its arrival back on the balance. As Shags do not feed at night (pers. obs.) a bird's mass in the early morning prior to the first feeding trip of the day was assumed to be equal to its mass with an empty gut. The mass of food caught during a trip, and subsequently brought back to the nest, was calculated relative to this "empty mass" i.e. mass on return minus day-specific empty mass. The empty mass was also used as a starting mass for second or third trips made during a day since we noted that Shags defaecated vigorously as they flew off at the start of these trips. We interpreted this as a bird clearing its digestive system before starting to feed thereby reducing the weight carried when flying to the feeding area. Two of the nest balances were watched from a hide located 10m away from the colony. Observations were made between dawn and 1600 h on three days and were used to calibrate changes in total nest mass with the activity of adults and chicks (Grémillet *et al.* 1996).

While the balance system was operating, concurrent measurements of feeding trip activity were determined for five of the eight adults by radiotelemetry. Foraging locations and different activities were determined from changes in signal direction and characteristics (full details in Wanless & Harris 1992). Dives were identified as breaks in signal transmission and periods spent flying were characterised by a strong steady signal. Times when the signal changed were noted

and used to calculate the duration of: 1) time out (TO), the interval between the bird getting off the balance and starting to dive and 2) time in (TI) the interval between surfacing after the last dive and arrival back on the balance.

Because feeding trips made by Shags can last several hours and digestion in piscivorous birds is typically rapid (e.g. Jackson 1992, Wanless & Harris 1992), in some cases the mass of food brought back to the nest by an individual Shag ("uncorrected load") does not represent the total amount of food caught during the trip. We therefore estimated the actual intake ("corrected load") using the method devised by Grémillet *et al.* (1996) in which the mean mass loss per unit time is predicted from the evacuation rate of the food, the prey size and the TB, TO and TI of the bird. Values for the evacuation rate were taken from Jackson (1992) and prey size was assumed to be either 1.8g or 4.8g depending where the bird foraged (Wanless *et al.* submitted).

Three Shags which had been weighed automatically after returning from the first feeding trip of the day, were caught and stomach flushed. Each bird was flushed three times, or until the run-off water was clear indicating that the stomach was empty. Flushings were filtered carefully through a fine gauge sieve, the prey remains drained for 45 min and then weighed to the nearest gram (Wanless *et al.* 1993). We considered that the mass of food lost in the run-off water used in the stomach flushing was negligible and therefore the difference between the uncorrected load, determined from the balance data, and the drained mass of the stomach flushing was used to estimate the amount of food which had already passed out of the stomach and into the intestine when the bird arrived back on the nest.

Work on excretion rates was carried out (under licence) on Foula, Shetland (60°08'N, 02°05'W) in late May 1995. Five non-breeding adults were caught and placed in individual wire-mesh cages lined with plastic. After digestion of their last meal was complete (around 18 hours) each bird was fed with sandeels *Ammodytes marinus* which had been caught 2 weeks earlier and stored at -20°C until needed. Excreta from the birds were collected on plastic trays positioned underneath the cages. Collections were made every 2 hours until digestion was complete and the net weight of excreta produced in each time interval was determined. Feeding conditions in terms of meal size, prey size and species for the five captive birds (173.72 ± 10.7 g, sandeels 10-13 cm in length) were broadly similar to those of free-living Shags on the Isle of May (167.3 ± 84.6 g, $n = 97$ loads; sandeels 6 - 14cm; Wanless, Grémillet and Harris, unpublished data).

RESULTS AND DISCUSSION

In each case ($n = 3$) the load weight determined by stomach flushing was less than the uncorrected load calculated from the increase in adult body mass during the trip. There was no evidence that this was because material was lost in run-off from the stomach flushing and it therefore appeared that some food had passed out of the stomach (but was still in the intestine) by the time the bird returned to the nest (Table I). The percentage of the load which had been digested was 18, 57 and 63% respectively. The digested masses showed the same order of ranking as the time elapsing between the end of diving and arrival back at the nest and suggested that the rate of stomach emptying was in the range 0.6-1.3 g/min.

To estimate the mass of material which had been defaecated by the time a bird arrived back on the nest, the uncorrected load was subtracted from the corrected load. In 14 of 24 (58%) trips there was no difference between the two values. In the 10 cases where values differed the mean (\pm SD) difference was 17.3 ± 3.2 g (range 13-21g). This figure was similar to the mean mass of an adult's defaecation determined from visual observations of two of the nest balances in which changes in total nest mass were related directly to the activity of the birds (22.0 ± 15.0 g, $n = 16$ defaecations). Overall, the mean difference between the corrected and uncorrected load was 7.2 ± 1.0 g and the time elapsing between the cessation of diving and a bird's arrival back on the balance was 65.3 ± 46.5 min ($n = 24$). This rate accorded well with results from the captive birds which indicated that in the 2 hours after feeding, the mean mass of excreta produced was $21.58 \pm$

TABLE I. LOAD MASSES ESTIMATED BY STOMACH FLUSHING AND CHANGES IN ADULT BODY MASS FOR THREE SHAGS REARING CHICKS. THE DIFFERENCE BETWEEN THE TWO VALUES WAS USED TO ESTIMATE THE AMOUNT OF FOOD WHICH HAD PASSED OUT OF THE STOMACH BY THE TIME THE BIRD RETURNED TO THE NEST.

Bird	Uncorrected load (g)	Stomach flushing (g)	Digested mass (g)	Time since last dive (min)	Digestion rate (g/min)
A	166	62	104	128	0.8
B	115	94	21	38	0.6
C	137	59	78	61	1.3
Average	139	72	68	76	0.9

9.30 g ($n = 5$) (Table II). Excretion rate peaked 2 - 4 hours after feeding and then declined until digestion was complete after about 22 hours. The total mass of excreta produced averaged 98.70 ± 4.00 g, which represented $56.9 \pm 2.5\%$ of the original meal mass.

Our results indicate that under a foraging regime typical of chick rearing, relatively little of the food load was lost as faeces, but some material had already passed out of the stomach and into the intestine by the time an adult Shag returned to its nest. The study therefore supports the hypothesis that adults digest some of their food load before they return to the brood (Wanless *et al.* 1993) and that consequently stomach flushings underestimate the amount of prey caught during a feeding trip (Grémillet & Plös 1994). Although a bird usually feeds its brood when it returns, chick-feeding bouts can occur after the adult has been present on the nest for several hours (pers. obs.). Thus although stomach flushings provide an estimate of the maximum amount of food potentially available for the brood, it is likely that digestion continues after the adult has returned to the nest and thus the amount actually fed to the chicks will be less than this. Clearly further work is needed to investigate the factors influencing the allocation of food loads between the adult and its brood.

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TABLE II. MEAN (\pm SD) MASS OF EXCRETA PRODUCED AND PRODUCTION AS A PERCENTAGE OF MEAL MASS FOR FIVE CAPTIVE NON-BREEDING SHAGS IN RELATION TO TIME SINCE FEEDING.

	Time since feeding (hours)					
	0-2 Mean \pm SD	2-4 Mean \pm SD	4-6 Mean \pm SD	6-8 Mean \pm SD	8-10 Mean \pm SD	10-12 Mean \pm SD
Mass of excreta (g)	20.54 \pm 7.33	28.96 \pm 5.07	20.88 \pm 5.43	10.36 \pm 5.43	6.48 \pm 5.73	4.92 \pm 2.11
Excreta produced (% meal mass)	9.36 \pm 3.32	12.73 \pm 2.13	9.41 \pm 2.89	4.44 \pm 2.08	2.68 \pm 2.19	2.21 \pm 1.04

SUMMARY

This paper presents information on defaecation rates and the amount of food estimated to have passed out of the stomach and into the intestine by the time an adult Shag returned to its brood after a feeding trip. Data collected using an automatic nest balance system, radiotelemetry and stomach flushing indicated that 18-63% of the food load had already passed out of the stomach into the intestine (and was hence unavailable to the brood) by the time an adult returned to the nest. Data on excretion rates obtained for five captive Shags indicated that rates peaked 2 - 4 hours after feeding and then declined until digestion was complete about 22 hours later. Results from the nest balances suggested that on 58% of trips (n = 24) no material had been defaecated before the bird arrived back at the nest after a feeding trip.

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S. Wanless and M. P. Harris, Institute of Terrestrial Ecology, Banchory Research Station, Hill of Brathens, Banchory, Kincardineshire AB31 4BY, UK.

D. Grémillet, Institut für Meereskunde, Düsternbrooker Weg 20, D-24105, Kiel, Germany.

G. M. Hilton, Applied Ornithology Unit, Division of Environmental and Evolutionary Biology, Graham Kerr Building, Glasgow University, Glasgow G12 8QQ, UK.

Ectoparasites from the Balearic Shearwater *Puffinus yelkouan mauretanicus*

R.L. Palma, R.L.C. Pilgrim and J.S. Aguilar

INTRODUCTION

The Balearic Shearwater, *Puffinus yelkouan mauretanicus* Lowe, 1921, breeds only on islands of the western Mediterranean Sea, mainly in the Balearic archipelago. It migrates through the Strait of Gibraltar up the west coast of Europe, reaching as far as Norway (Jouanin & Mougín 1979). Ectoparasitic insects of the Balearic Shearwater are poorly known. Edwards (1961) recorded one species of feather louse, *Halipeurus diversus* (Kellogg, 1896), based on four females taken from skins preserved in museum collections. Beaucournu and Alcover (1993) commented that the flea, *Xenopsylla gratioiosa* Jordan and Rothschild, 1923, had been found on *P. y. mauretanicus* from Mallorca, without giving further details. We report recent collections made by J.S.A. from birds caught alive in breeding colonies on the Balearic Islands, which confirm the two insects mentioned above as regular ectoparasites of that petrel. Voucher specimens have been deposited in the collection of the Museum of New Zealand, Wellington, New Zealand.

The Balearic Shearwater was originally regarded as a race of the Manx Shearwater, *Puffinus puffinus* (see Jouanin & Mougín 1979), but its phylogenetic relationships and consequent taxonomic position have been a matter of debate over the last two decades (Bourne *et al.* 1988, Walker *et al.* 1990). We use the combination *Puffinus yelkouan mauretanicus* in this paper, following the nomenclatorial arrangement given by Bourne *et al.* (1988). Further research on the ectoparasites of the Balearic Shearwater and of the Levantine Shearwater, *Puffinus yelkouan yelkouan* (Acerbi, 1827), may help to elucidate their true relationships.

RESULTS

During May - June 1995, 19 individual birds (18 chicks and one adult) from four breeding localities were searched for ectoparasites, using a method comparable to that followed by Fowler and Shaw (1990). One chick yielded no lice or fleas. A total of 314 lice of the species *Halipeurus diversus* (Phthiraptera: Philopteridae) were found on 17 hosts (16 chicks and one adult), and 180 specimens of the flea *Xenopsylla gratioiosa* (Siphonaptera: Pulicidae) were collected from 10 chicks (Table I). Both species were taken from nine chicks.

DISCUSSION

The louse *Halipeurus diversus* is widespread on a number of *Puffinus* species inhabiting the Atlantic and the Pacific Oceans (see Edwards 1961). In the Mediterranean Sea, *H. diversus* has been found on the Levantine Shearwater as well as on the Balearic Shearwater.

In their study of the louse fauna from 230 live Manx Shearwaters, *Puffinus puffinus puffinus* (Brünnich, 1764) in Wales, Fowler and Shaw (1990) recorded eight louse species. Among them, *H. diversus* and *Trabeculus aviator* (Evans, 1912) were found on 99.5% of the birds examined, while *Austromenopon paululum* (Kellogg and Chapman, 1899) was present on 13.5%. The remaining five species showed an extremely low infestation rate. Considering that the collecting method applied by J.S.A. for the present study is comparable to that used by Fowler and Shaw and that *Trabeculus* lice have been recorded from most *Puffinus* species, the absence of any *Trabeculus* specimen from our samples may be significant. Further collecting from the Balearic Shearwater is needed to validate that absence, as well as to ascertain the status of *Austromenopon*

TABLE I. ECTOPARASITES COLLECTED FROM BALEARIC SHEARWATERS IN FOUR BREEDING LOCALITIES (M: males; F: females; N: nymphs; w.o.: weeks old)

Locality	Number of birds	<i>H. diversus</i> (No. of hosts)	<i>X. gratioxa</i> (No. of hosts)
Cueva de Sa Cella (Mallorca Island)	1 adult 11 chicks (ca 4 w.o.)	4 M, 7 F, 4 N (1) 10 M, 13 F (9)	0 12 M, 65 F (8)
Cova dels Porxos Cap de Berberia (Formentera Island)	2 chicks (ca 8 w.o.)	8 M, 10 F (2)	3 M, 100 F (2)
Tagomago Islet (off Ibiza Island)	2 chicks (ca 7 w.o.)	46 M, 64 F, 3 N (2)	0
Cueva La Llumeta Conills Islet (off Cabrera Island)	3 chicks (ca 9 w.o.)	79 M, 66 F (3)	0
TOTALS	19	147 M, 160 F, 7 N (17)	15 M, 165 F (10)

and any other lice which might possibly parasitise it. In particular, finding the louse *Saemundssonina kosswigi* Timmermann, 1962 (currently known only from the Levantine Shearwater) would be significant evidence towards confirming the apparent close relationship of the two Mediterranean *Puffinus* populations.

The flea *Xenopsylla gratioxa* has been recorded from the breeding grounds of several petrel species on many islands of the Mediterranean Sea and the north Atlantic Ocean, including Cory's Shearwater, *Calonectris diomedea* (Scopoli, 1769), on the Balearic Islands (Beaucournu & Alcover 1993).

In their study of the ectoparasites of Cory's Shearwaters, Wink *et al.* (1979) found three species of lice (predominantly *Halipeurus abnormis* (Piaget, 1885)) on adult birds as well as on 6-8 weeks-old chicks. Lice were markedly less common on the chicks. However, chicks were also parasitised by an average of 40 or more fleas, *X. gratioxa*. Fleas were absent from the adult birds.

In our study (Table I) the chicks from Tagomago and Conills Islets yielded no fleas but many more lice per bird than did the adult and the chicks from Mallorca and Formentera Islands; many fleas were obtained from these last two collections, all of them on chicks.

Our results are not dissimilar from those of Wink *et al.* (1979), and the inverse ratios of lice:flea loads may be significant. However it must be borne in mind that, while lice and (adult) fleas are both obligate parasites, lice are permanently resident on the host whereas (bird) fleas tend to frequent the nest itself, temporarily infesting the bird mainly for feeding. Examination of the bird itself may not reveal the true flea infestation of adult birds; young birds confined in nests, on the other hand, more frequently harbour fleas as well as, occasionally, even flea larvae (R.L.C.P. unpublished).

The only adult bird searched for ectoparasites in the present study yielded 11 adults and four nymphs of *H. diversus*, but only one of the 16 chicks parasitised by *H. diversus* had nymphs (3).

This very low proportion of immature *Halipeurus* lice on Balearic Shearwater chicks is also consistent with the findings of Wink *et al.* (1979) for the species *H. abnormis* on young Cory's Shearwaters.

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SUMMARY

Two species of insect ectoparasites were found on 18 Balearic Shearwaters (*Puffinus yelkouan mauretanicus* Lowe, 1921) from breeding localities in the Balearic Islands, during May and June 1995. The louse *Halipeurus diversus* (Phthiraptera: Philopteridae) was collected from 17 birds and the flea *Xenopsylla gratioa* (Siphonaptera: Pulicidae) from 10 birds. Both species were taken from nine birds.

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R.L. Palma, Museum of New Zealand, P.O. Box 467, Wellington, New Zealand.

R.L.C. Pilgrim, University of Canterbury, Private Bag 4800, Christchurch, New Zealand.

J.S. Aguilar, 07001 Palma de Mallorca, Islas Baleares, Spain.

The first record of North Atlantic Gannets *Morus bassanus* breeding in Russia

Yuri V. Krasnov and Robert T. Barrett

INTRODUCTION

The North Atlantic Gannet *Morus bassanus* is a common species in the North Atlantic with its main centre of distribution in Britain. Since the beginning of this century, its population has risen at a rate of 2-3% p.a. (Nelson 1978, Wanless 1987). The first Norwegian Gannet colony was established on Runde, south-west Norway in 1946 (Valeur 1947), and the first North Norwegian colony in 1961, at Syltefjord in East Finnmark (Fig. 1) (Brun 1967). In 1995, there were four colonies in North Norway with a total population of ca. 2200 pairs (Barrett & Folkestad 1996). With the rapid population increase in North Norway, observations of several attempts to breed at other sites in the region (Barrett & Folkestad 1996), and a steady increase in numbers observed off the Kola Peninsula, Murman since the mid 1970s (see below), the first attempt by Gannets to nest in Russia has been anticipated (Barrett & Folkestad 1996). This note presents documentation of the establishment of the first Russian breeding site, the laying of the first egg, and the food and foraging behaviour of these first immigrants.

METHODS

All observations of Gannets in Murman were noted during annual seabird field work on the Seven Islands archipelago and periodic surveys along other stretches of the Barents Sea coast since 1977. In 1991-1996, their foraging behaviour was observed from Kharlov (68°49'N, 37°20'E, Fig. 1), an island in the Seven Islands archipelago using a 60x telescope. Birds were aged on the basis of plumage characteristics. The sizes of food items were estimated from direct observations through comparisons with the bill size, and by comparison with food items collected from Kittiwakes *Rissa tridactyla*, Herring Gulls *Larus argentatus* and Great Black-backed Gulls *L. marinus*.

RESULTS

The first observations of Gannets in Murman

The first documented observations of Gannets in Murman are single sightings in Kandalaksha Bay in the White Sea (Fig. 1) in summer 1968 and 1976 and one near Lumbovskii Bay (Fig. 1) in June 1974 (Kokhanov & Skokova 1967, Shklyarevich & Kokhanov 1980). Since 1977, they have become regular visitors to the waters off the Kola Peninsula being seen annually off the Seven Islands. Until 1981, only solitary birds were recorded, but later small groups of two or three birds appeared. They were seen regularly on passage along the coast, or very rarely resting on the cliffs. The sudden sightings of Gannets in coastal waters near the Ainov Islands (69°50'N, 31°35'E, Fig. 1) in western Murman over the two month period August-September 1988 was thus recorded as "unusual" by the observers (Tatarinkova & Chemyakin 1995). In the early 1990s, similar appearances were recorded in the more easterly parts of Murman, and in 1992, groups of immature and adult Gannets were sighted off the Seven Islands throughout the summer.

The establishment of the first Russian breeding site

The first record of a Gannet prospecting a site in Russia was made in 1993, when a pair of 3-4 year old Gannets occupied and regularly visited a site in a colony of Common Guillemots *Uria*

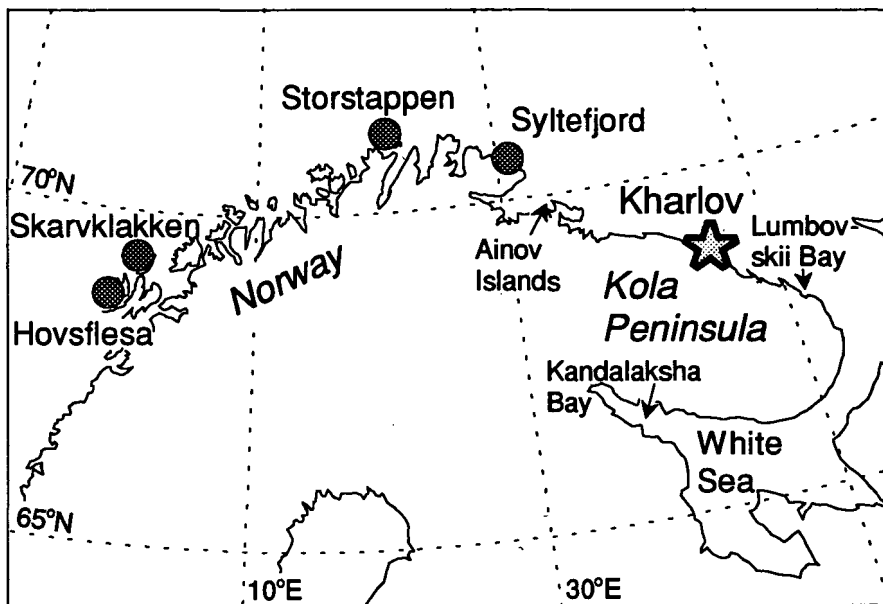


Figure 1. Positions of the first record of North Atlantic Gannets breeding in Russia (star), extant Gannet colonies in North Norway (circles) and other localities mentioned in the text.

aalge on Kharlov. One of the pair was ringed. In 1994, however, the site remained vacant despite Gannets being constantly observed in the area near the colony.

In 1995, the number of Gannets in the coastal waters of eastern Murman increased appreciably. During one 60 km long boat transect out from Kharlov on 14 June 1995, the density of Gannets was estimated to 0.6 birds/10 km². During the second half of the summer, up to three pairs of Gannets visited the site occupied in 1993. Two of the pairs were in adult plumage, while the third pair consisted of three year old birds. One of the adult birds was ringed (probably the same bird seen in 1993), and a control with a telescope showed that it was ringed as a chick in 1991 (by R.T.B.) at the recently established colony at Storstappen near the North Cape in Norway (71°08'N, 25°20'E, Fig. 1), ca. 550 km west of Kharlov. All birds occupying the sites showed elements of breeding behaviour, including the "adoption" of guillemot chicks from neighbouring sites (see also Fairhurst 1976). One pair started building a nest on 7 August, and completed it over the next 10 days. Although birds were seen in the incubation position, no egg was ever seen and it is assumed that laying did not occur. They left the island around 20 August.

In 1996, only one pair built a nest, primarily of seaweed *Fucus* spp. which they collected from the surface of the sea. The nest was on the same site as in 1995, and was nearly finished by June 5 after which one of the birds was constantly at the nest. Mating was observed for the first time at the nest on 11 June, and again on 15 June. The single egg was laid on 17 June, and was incubated at least until the end of June when Y.V.K. left the island.

Feeding behaviour and food

Gannets feed commonly on pelagic fish and in North Norway their diet consists mainly of herring

Clupea harengus, saithe *Pollachius virens*, sandeels *Ammodytes* sp. and probably also capelin *Mallotus villosus* (Brun 1972, Montevecchi & Barrett 1987).

In July 1991, first-year and immature Gannets were observed feeding on small shoals of sandeels near Kharlov. They were feeding around the periphery of large flocks of gulls where the fish were probably just too deep for the gulls to reach. The Gannets were shallow-diving by swooping in at a low angle. Sometimes they were alone over sandeel shoals, and then they fed by alighting on the surface and head dipping. In all cases observed, the Gannets caught several sandeels at once, and 5-6 fish could be seen trailing from their beaks. The fish were ca. 120-170 mm long. Some were sometimes lost to kleptoparasitic Herring and Great Black-backed Gulls. Gannets were also seen feeding on sandeels in 1992.

In 1993-1996, capelin (120-130 mm) and some sandeels were observed being caught by the birds occupying the breeding site on Kharlov. Several herring were also seen in 1995. These fish were caught either close inshore (1.5-2 km from the colony) in 1993, or further offshore in 1995 and 1996.

DISCUSSION

The establishment of Gannets as a breeding species in this part of Russia is a not unexpected consequence of the recent rapid increase in the North Norwegian population, and the large degree of intercolony movement made by the birds of the region (Barrett & Folkestad 1996). That they chose Kharlov as the first site is probably because the island has one of the largest cliff-breeding seabird colonies on the Kola Peninsula (ca. 20,000 pairs of Kittiwake, ca. 1000 Brünnich's Guillemot *U. lomvia* individuals, and ca. 3000 Common Guillemot individuals), and is situated close to a relatively large, local stock of sandeels (Krasnov & Barrett 1995). Such a stock of rich and seasonally predictable fish is a prerequisite for successful breeding in Gannets (Nelson 1978), whereas the irregular appearance of capelin and herring near the colony is an additional, but not predictable benefit (Dragesund *et al.* 1980, Barrett & Krasnov 1996). Furthermore, the topography of the cliffs with irregular formations and numerous wide and gently sloping shelves is also favourable for Gannet nesting.

ACKNOWLEDGEMENTS

We thank Natalie G. Nikolaeva for her help in translating an early draft of this manuscript from Russian to English, and the Norwegian Directorate for Nature Management for funding our collaborative studies.

SUMMARY

After a ca. 20 year period of increasing numbers in the waters off Murman, the first Gannet nest for Russia was built on Kharlov in the Seven Island archipelago, off the Kola Peninsula in 1995, and the first egg was laid in 1996. One of the first pioneering birds had been ringed as a chick in a North Norwegian colony in 1991. Gannets were seen feeding mainly on sandeels, but also on capelin and herring.

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Yuri V. Krasnov, Kandalaksha State Nature Reserve, Kandalaksha, Murmanskaya obl., Russia 184040.

Robert T. Barrett, Tromsø Museum, Zoology Department, University of Tromsø, N-9037 Tromsø, Norway.*

*Address for correspondence.

Differences in prey species delivered to nestlings by male and female Razorbills *Alca torda*

Richard H. Wagner

INTRODUCTION

Several studies have reported information on nestling provisioning by Razorbills *Alca torda* (reviewed by Bradshaw & Brown 1985). Data exist on feeding rates and the species of fish brought to the nest (Lloyd 1977; Harris & Wanless 1986), diving behaviour (Wanless *et al.* 1988) and the relative contribution of the sexes (Wagner 1992a). However, nothing is known about possible differences in feeding behaviour of males and females. Here I report that on Skomer Island, Wales, males and females showed a significant difference in the species composition of prey fish they delivered to nestlings.

METHODS

I recorded Razorbill feedings at the Basin colony on Skomer Island, from 4 June - 1 July 1989. Observations were made every morning from first light (0430 h) for at least 3 h. Two additional observers aided in feeding watches from 19 June - 1 July for 3 h in the morning (0500-0800 h and 0800-1100 h) and 3 h in the afternoon (ca. 1300-1600 h) and in total, we observed the colony for approximately 200 h. Thirty-seven numbered nests in which one or both adults were colour-ringed were visible, of which approximately 50% contained chicks on any day. The sex of marked individuals was determined previously by observing copulations, during which males invariably performed the mountings (Wagner 1992b). For each feeding event, the following information was recorded: the identity of the feeder, species of fish, number of fish, and the estimated length of the fish (an average for the load), expressed as the proportion of the bill length (i.e. gape length, which averaged 53.9 mm for males 52.3 mm for females). To avoid slight but significant differences among observers in estimating fish size (Wagner 1992a), I compare males and females only from my own observations. Thus, the comparison of fish size was made on approximately half the data, while comparisons of fish species composition and number of fish were made on all of the data.

RESULTS

A total of 992 feedings were observed in which the species or genus of fish was identified, with 94% consisting of sandeels *Ammodytes* sp. and 6% consisting of Clupeids, while in four (0.4%) feedings, both were delivered. The several Clupeids that were recovered from the colony were identified as sprats *Sprattus sprattus*, and I assume that most or all Clupeids identified through binoculars were of this species. Sprats or mixed loads comprised 55 of 550 (10%) female deliveries compared with 7 of 442 (1.6%) of male deliveries. Thus, females delivered 89% of the loads comprising sprats. One female was a sprat "specialist", with sprats comprising 16 of 30 (53%) of her loads, and another female delivered sprats in 8 of 19 (42%) deliveries. The overall higher percentage of sprat deliveries by females was not an individual effect however, because only 2 males out of 28 (7%) delivered at least one sprat, compared with 14 of 34 (41%) females ($\chi^2 = 11.3$, $P < 0.001$). Among sandeel loads, there was no significant difference in the lengths of fish brought in by each sex. Sandeels carried by females averaged 1.44 bill-lengths (sd = 0.26, $N = 231$) (approximately 75 mm) compared to 1.43 (sd = 0.21, $N = 235$) (approximately 77 mm) by males (t-test: $t = 0.50$, $P = 0.62$). However, females delivered a significantly larger number of

sandeels per load than males (females: mean = 7.66, SD = 2.61, N = 231; males: mean = 7.02, SD = 2.68, N = 233; $t = 2.6$, $P < 0.01$). In contrast to loads of sandeels, sprats were usually delivered singly, with the number of sprats per load averaging 1.2 (SD = 0.52, N = 59). When the loads of fish were converted to weight, there was no significant difference in the amount of food delivered by each sex (Wagner 1992a).

DISCUSSION

This is the first study able to examine in Razorbills whether a sex difference exists in the prey species delivered to nestlings. Although sprats comprised a minority of feedings, it is intriguing that females delivered markedly more sprats than males. If such differences occur in other locations and times, it would be impossible to detect without a marked population of known-sex individuals, which most previous studies have lacked. On the Isle of May, which did have a marked population, 98% of feedings were of sandeels (Harris & Wanless 1986), suggesting that the local availability of prey species may not have permitted potential individual or sex differences to occur. An implication of relative female preference for sprats is that the sexes may employ somewhat different foraging skills. Intra-sexual differences in the proportion of sprats delivered among females also suggests that there may be substantial variation in foraging strategies among individuals. A more general ecological implication of these findings is the possibility that some degree of feeding niche separation may occur between the sexes. This idea partially assumes that the prey items that parents feed their chicks represent those that the adults themselves consume, a question that might require examining the stomach contents of adults.

An interspecific separation of feeding niches or foraging strategies may exist between Skomer Island Razorbills and Common Guillemots *Uria aalge*, because prior to this study, Hatchwell (1991) reported that 65-81% of Skomer Guillemot feedings comprised sprats. If Guillemots typically favour sprats while Razorbills in the same area favour sandeels, it could suggest that some female Razorbills may be pursuing similar foraging strategies to Guillemots.

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I thank Mark Linfield and Stuart Perry for field assistance and the Dyfed Wildlife Trust for permission to work on Skomer Island.

SUMMARY

I observed nestling provisioning by known-sex Razorbills on Skomer Island, Wales. Of 992 feedings, 94% were of sandeels and 6% were of sprats. There was a significant sex difference in the species composition of loads, with sprats comprising 10% of female loads compared to only 1.6% of male deliveries. This difference raises the question of whether differences exist in the fish species that adults consume, and if a degree of feeding niche partitioning might occur between the sexes.

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BOOK REVIEWS

WARHAM, J. 1996. The behaviour, population biology and physiology of the petrels. Academic Press, London. 613pp. £60.00. ISBN 0-12-735-4158.

John Warham has worked on petrels for most of his career. In 1990, he published the first of a projected pair of books on this group (The petrels: their ecology and breeding systems), and nearly all reviewers hailed its scholarship and accuracy. This is the eagerly awaited second volume. I am very pleased to report that the wait has been worth it. There are twelve chapters on a wide variety of topics. The first chapter deals with petrel populations covering population size, aspects of breeding biology, including productivity, mortality and habitat selection. The next two chapters concern birds at sea, covering distribution, dispersal, migration and feeding. I found the only obvious error in the book with the mismatch between the figure and caption of Figure 2.1 in Chapter 2. Since this relates to some of our work in Aberdeen, I know why the error occurred - the figure was changed late on in the production process in an effort to keep the publication as up-to-date as possible!

The fourth, fifth and sixth chapters cover behaviour, with a general introduction followed by more specific accounts of the behaviours within the various petrel families. Vocalisations are thoroughly covered with extensive use of sonograms. The author even includes a sonogram of the Røst, Norway lighthouse engine that is known to attract storm petrels. Physiology, energetics and biochemistry are summarised in the following two relatively short chapters. The biochemistry of pollutants is covered here. Not surprisingly, the following chapter on locomotion mostly describes flight. However the section on underwater locomotion may surprise some. How many people are aware that the mean maximum diving depth of sooty shearwaters is 38m, or that many species can reach 3-5m depth? The chapter on anatomy brings together and adds to much of the information in the earlier petrel volume.

The penultimate chapter, on evolution and radiation covers the wide variety of possible relationships, both within the group and between it and other groups. The author looks forward to the resolution of the divergent views on relationships. I was very interested in the fossil record, and was intrigued by the dating of fossil layers of stomach oil from the Antarctic indicating colonisation at least 35,000 years ago. The final chapter describes the relationships between humans and petrels. Petrels have been used widely as food and some have been kept in captivity. Conservation actions are described. The final section of the book is fittingly about by-catch in fisheries. This activity seems the likeliest of man's influences to make any petrel species extinct, and the area where concerted international action is required to relieve the pressure on petrel populations. The book is completed with 64 pages of references.

Inevitably in a book covering such a widely researched group as the petrels, an author carrying out a summary survey such as this has to be very selective. In the areas I know best (mostly birds at sea), the selection of studies summarised and the conclusions drawn could hardly be bettered. I can but admire the scholarship that has gone into the book. It is as up-to-date as possible and coupled with the predecessor volume, about as comprehensive as anyone wishing to learn about this most marine of bird groups could need. I unreservedly recommend this book.

Mark L Tasker

SKJOLDAL, H.R., HOPKINS, C., ERIKSTAD, K.E. and LEINAAS, H.P. 1995. Ecology of fjords and coastal waters. Elsevier, Amsterdam, 623pp. ISBN 0-444-82096-5.

This well-produced book contains the Proceedings of the Mare Nor Symposium on the Ecology of Fjords and Coastal Waters, Tromsø, Norway, 5-9 December, 1994. The section on Seabird Ecology includes seven papers of interest to the readers of Seabird. These are listed below to encourage you to read them:

Spatial and temporal scaling of energy flux through populations of marine nekton (pages 419-428)

D.C. Schneider

Remote-recording of foraging patterns in seabirds and seals for studies of predator-prey interactions in marine systems (429-442)

J.P. Croxall

Large-scale interactions among seabirds, their prey and humans in the southern Barents Sea (443-456)

J.V. Krasnov and R.T. Barrett

Energy expenditure and food consumption by seabird populations in the Barents Sea region (457-471)

F. Mehlum and G.W. Gabrielsen

Adult survival and chick production in long-lived seabirds: a 5-year study of the kittiwake *Rissa tridactyla* (471-478)

K.E. Erikstad, T. Tveraa and R.T. Barrett

Prolonged incubation in the Atlantic puffin *Fratercula arctica* and evidence of mild hypothermia as an energy-saving mechanism (479-488)

R.T. Barrett, G.W. Gabrielsen and P. Fauchald

Long-term changes in the helminth fauna of colonial seabirds in the Seven Islands archipelago (Barents Sea, Eastern Murman) (489-496)

K.V. Galaktionov

Other topics covered in the book include physical processes and seasonal patterns, fronts, advection and distributional patterns, harmful algae, influence of human activity in arctic waters, fish ecology and stock interactions, and ecology and biology of kelps and sea urchins.

M.P. Harris

THE SEABIRD GROUP 1997

The Seabird Group was founded in 1966 to circulate news of work in progress on seabirds and to promote research. It is run by an elected Executive Committee and maintains close links with the three major British national ornithological bodies – the British Ornithologist's Union, the British Trust for Ornithology, and the Royal Society for the Protection of Birds. Membership (£10 per annum, £9 if paid by banker's order, £5 for students) is open to all with an interest in seabirds; for details please contact the Membership Secretary (address below) – payment by banker's order helps the Group.

Current Executive Committee The present Committee comprises: Chair S. Wanless, Secretary J. Uttley, Treasurer R.W. Furness, Membership Secretary S. Russell, Editor of *Seabird* S. Wanless, Newsletter Editor M. Tasker, also K.C. Hamer, G. Mudge, J.D. Okill, E.K. Dunn and S. Sutcliffe.

Newsletters and Meetings Three Newsletters are circulated to members each year. They contain all sorts of items including reports on seabird conservation issues and research projects, news from seabird groups in other countries, book reviews, details of meetings, etc. The Newsletter Editor (address below) welcomes contributions from members. The usual venue for the Group's annual meeting is the BTO Ringing and Migration Conference at Swanwick, except when the Group holds its own conference, in which case the meeting is combined with that. Our conferences draw seabird workers from many countries to join in a forum of topical interest. In keeping with our desire to promote work in the field, practical manuals and guidelines evolve from the workshop sessions which cater for specialist topics within the conference theme.

Seabird Group Grants Each year the Group has some money available to help fund research conducted by members. All grant applications should be submitted to the Secretary by the end of February, and will be considered by the Executive Committee by the end of March. Successful applicants are required to submit a typed report, not exceeding 500 words, by the end of October of the same year for inclusion in the Newsletter. A full typed report (in triplicate) must be submitted by the end of the year.

Seabird Colony Register The Seabird Group has always sought to organise and implement national schemes involving the active participation of its membership, now standing at 350 members. The Group membership played a major role in the national Operation Seafarer survey whose results were published in 'The Seabirds of Britain and Ireland' (1974). The Group completed the Seabird Colony Register fieldwork in 1988, in cooperation with the Nature Conservancy Council, and the results were published in the book: 'The Status of Seabirds in Britain and Ireland' in 1991. This register was begun in 1985 to gather together all existing data on breeding seabird numbers in the British Isles, to bring our knowledge of their status up to date by detailed field surveys and to establish a computerised database which can be easily updated in the future. Although this round of survey work has been completed, it is important to continue monitoring of seabird breeding numbers: anyone eager to conduct counts on a regular basis should contact Kate Thompson, JNCC, Seabirds and Cetaceans Branch, Dunnet House, 7 Thistle Place, Aberdeen AB10 1UZ, UK.

Seabird Journal In November 1984 the Group launched its new-look journal *Seabird*, numbered 7 in deference to its pedigree of Seabird Group Reports 1-6. Our priority is to maintain a high volume and quality of content and the current editor, Sarah Wanless, welcomes offers of papers (see Notice to Contributors, and address below). Members of the Seabird Group receive *Seabird* free of charge; additional copies to members, and any copies to non-members are £10 + 50p postage within the British Isles, £10 + £1 postage overseas. Postage overseas is by surface mail, unless the recipient can make prior provision for air mail. The subscription to Libraries is £15 per copy. To help reduce costs, overseas subscribers are kindly asked to make payment by international money order rather than by cheque. Back issues of *Seabird* 11 - 18 are available at

£5 + 50p postage per copy. There are no cost concessions for multiple orders of *Seabird* and postal charges are additive.

Who to write to While the Seabird Group maintains an accommodation address (c/o RSPB, The Lodge, Sandy, Bedfordshire SG19 2DL, UK), the following can be contacted directly, as appropriate. Please help the Group by enclosing a stamped addressed envelope for reply.

Secretary (general enquiries about the Group, seabird conservation matters, grants, etc.): Dr John Uttley, SNH, Ground Floor, Stewart Building, Alexandra Wharf, Lerwick, Shetland ZE2 9LX, UK.

Membership Secretary (membership renewals, applications and enquiries): Sheila Russell, Clober Farm, Craigton Road, Milngavie, Glasgow G62 7HW, UK.

Treasurer (subscriptions, donations, etc.): Dr Robert Furness, Department of Zoology, University of Glasgow, Glasgow G12 8QQ, UK.

Editor of Seabird: Dr Sarah Wanless, Institute of Terrestrial Ecology, Hill of Brathens, Banchory, Kincardineshire AB31 4BY, UK.

Newsletter Editor: Mark Tasker, JNCC, Dunnet House, 7 Thistle Place, Aberdeen AB10 1UZ, UK.

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NOTICE TO CONTRIBUTORS

Seabird publishes original contributions relating to any aspect of seabird ornithology as full-length papers (preferably not exceeding thirty manuscript double-spaced pages) or short notes. Although a portion of the journal will be of particular interest to UK members, contributions are welcomed on aspects of seabird ornithology from any part of the world so long as they are likely to be of general interest.

Seabird is indexed in the Aquatic Sciences and Fisheries abstracts, Ecology Abstracts and Animal Behaviour Abstracts of Cambridge Scientific Abstracts databases and journals.

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Contributions should be submitted in the same format as used in recent copies of *Seabird*, and this is outlined below:

All submissions, of which *three* copies are required, must be typewritten, on one side of the paper, with double spacing and adequate margins. The approximate position of figures and tables should be indicated in the margin. Authors are advised to consult a recent copy of *Seabird* and follow the conventions for section headings, tables, captions, references, quotation marks, abbreviations etc. The Editor may return without consideration any submission that departs from the *Seabird* form of presentation. Spelling should conform with the preferred i.e. first-cited spelling of the *Shorter Oxford Dictionary*. Details of experimental technique, extensive tabulations of results of computation procedures, etc. are best presented as appendices. A full-length paper must include a summary not exceeding 5% of the total length.

On first mention a bird species should be designated by an English vernacular name drawn from *The Status of Birds in Britain and Ireland*, or from an authoritative faunistic work treating the appropriate region, followed by systematic binomial; author and date need be cited only in taxonomic papers. Thereafter only one name should be used, preferably the English one. Capitals should be used for the initial letters of all single words or hyphenated vernacular names (e.g. Great Black-backed Gull, White-eyed Gull) but not in a group name (e.g. gulls, terns). Trinomials should be used only if the subspecific nomenclature is relevant to the topic under discussion. Underlining is used for all words of foreign languages, including Latin, other than those which have been adopted into English. Underlining should also be used for phonetic renderings of bird vocalizations. Underlining is not needed for emphasis.

Measurements should be given in SI (International system of units), but if the original measurements were made in non-SI units, the actual values and units should be given, with SI equivalents inserted in parentheses at appropriate points. Measurements may be given in cm.

Figures and diagrams should be drawn in black ink on white board, paper or tracing material, with scales (for maps), and lettering given in Letraset. In designing drawings, authors are asked to note the page-size and shape of *Seabird*; originals should be 1½-2 times final size. Tables should be typewritten and spaced appropriately. References should be quoted in the text in the format indicated by the following examples: Harris 1980, Cramp & Simmons 1980, Monaghan *et al.* 1980. References at the end of the paper (following acknowledgements) should be given in the following format:

COULSON, J.C. and WOOLER, R.D. 1976. Differential survival rates among breeding Kittiwake Gulls *Rissa tridactyla* (L.). *J. Anim. Ecol.* 45: 205-213.

The author's name should be placed beneath the title of the paper and again at the end, together with the address, after the references.

Twenty-five offprints of each original contribution will be supplied free. Additional copies can be supplied on payment; orders will be required at the time of proof-correction. Reprints of book reviews will only be supplied if a request is submitted with the original copy; in this case the full number will be charged at cost.