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The recolonisation of the Isle of May by Common and Arctic Terns

S. WANLESS

After an absence of 21 years Common and Arctic Terns recolonised the Isle of May in 1979 and 1984 respectively. The colony increased each year and in 1987, 76 Common and 126 Arctic Tern nests were found. The timing of breeding was consistently later than at nearby colonies but breeding output was much higher than at Aberlady Bay. Possible explanations for the terns' departure and re-establishment are discussed.

Introduction

Four species of terns bred on the Isle of May, Firth of Forth during the first half of the 19th century but the colony was abandoned about 1850. Terns bred again from 1921 to 1957 with numbers varying greatly from year to year (details in Eggeling 1960). Common Terns *Sterna hirundo* were particularly numerous in 1927 and 1936 and reached a peak of 5-6000 pairs in 1946-7; numbers of Arctic Terns *S. paradisaea* were highest in 1936 (800 pairs) and in 1946 (400-550 pairs) which was also the peak year for Sandwich Terns *S. sandvicensis* (1400-1500 pairs) and Roseate Terns *S. dougallii* (*c.*15-20 pairs). At its zenith in 1946 the colony held 6800-8100 pairs, but in subsequent years numbers of all species declined and breeding success was poor. For 24 years from 1958 there were only a few isolated breeding attempts, mostly by Common Terns (Eggeling 1974, Tasker 1979, Lack 1980, Bayes 1981). In 1982 a small colony of Common Terns was re-established and in 1984 Arctic Terns also resumed breeding. This paper documents these recolonisations.

Methods

To keep human disturbance to a minimum no detailed nest checks were made. However, each year visits of less than 20 minutes were made to the colony at approximately weekly intervals in good weather conditions. In 1982 nests were not marked but in 1983 clutches were numbered (felt tip pen on eggs). Since then all nests have been marked with short numbered stakes placed *c.*30 cm away from the nest. Occasional observations made from a temporary hide and/or the Lighthouse tower provided information on the extent of the colony each year, the species present and their biology. The species count for each year was the cumulative total of nests found. A few of these nests were almost certainly repeats after earlier failures and so the counts presented will slightly overestimate the number of breeding pairs. The locations of place names mentioned in the text are shown in Fig. 1.

Results

Numbers and distribution

Between 1958 and 1981 there were seven nesting records of Common Terns and one of Arctic Terns (Table 1). Four pairs of Common Terns bred in 1981 but the nests were widely scattered both in space and time and it was not until 1982 that a well-defined colony was established. During May 1982 increasing numbers of Common Terns displayed over North Plateau just north of

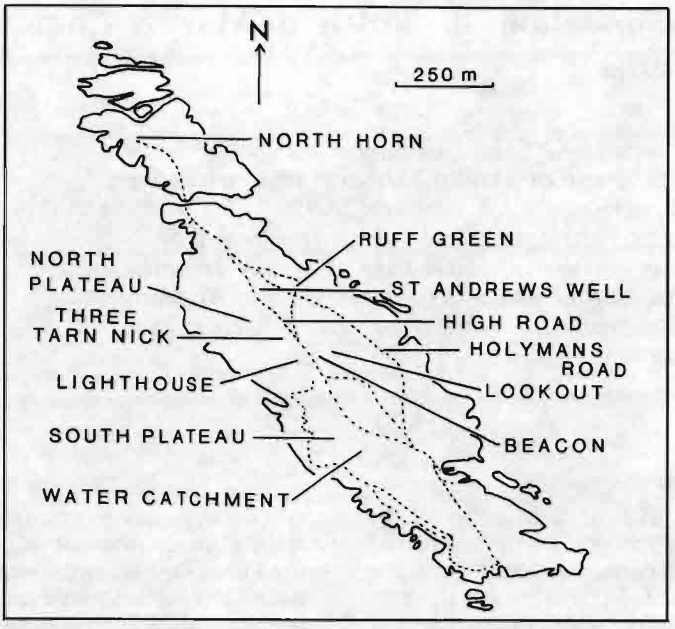

FIGURE 1 *Isle of May showing places mentioned in the text. The dotted lines indicate tracks.*

the Lighthouse and two nests with single eggs were found in an area of sorrel *Rumex acetosa* on 27 May. Fourteen nests were found that year and the number of birds present reached a peak of 52 on 26 July (Table 2). In addition, one pair of Common Terns nested near the Water Catchment on South Plateau. The North Plateau area was re-occupied in 1983 and 1984 when respectively 37 and 36 nests with eggs were found. In 1984 seven pairs of Arctic Terns arrived with an influx of Common Terns between 15 and 23 June and subsequently 19 pairs of Arctic Terns bred in an area of close-cropped turf and rock overlooking the Common Tern colony. A pair of Common Terns probably attempted to breed on South Plateau.

In 1985 the two species showed the same segregation in the North Plateau colony as in 1984, apart from an isolated pair of Common Terns which nested below the Beacon. Numbers continued to increase and 80 Common and 87 Arctic Tern nests were found. In 1986, the Arctic Tern was the most numerous species with an estimated 128 nests; only 22 Common Terns nested and the colony was more fragmented than previously. Sixty-five clutches, mainly of Arctic Terns, were found in their usual area on North Plateau. There was a second more dispersed sub-colony of 85 nests between the Beacon and Holyman's Road. At least 17 nests were Common Terns' and most of these were either on the concrete base of the old Lookout or in the tall vegetation on the ash heap below the Beacon. Most of the Arctic Tern nests were on the short-cropped turf towards Holyman's Road. Two pairs (? species) laid on the ridge running parallel to the High Road between the Lighthouse and Three Tarn Nick and another pair nested just south of St Andrew's Well. No terns bred in the area originally colonised. On 22 July following a helicopter incident, the North Plateau colony was entirely

TABLE 1 Details of breeding attempts by terns on the Isle of May, 1958-81. (Information taken from Eggeling 1974, Tasker 1979, Lack 1980 and Bayes 1981).

Year	Species of Tern	Location	Comments
1973	Common	Low Light - Tarbet	Nest with eggs, fate unknown.
1979	Common	Water catchment, South Plateau	Nest with one egg by 27 June. Failed.
1980	Arctic	Water catchment, South Plateau	Nest with two eggs on 5 July. Failed.
	Common	Water catchment, South Plateau	Nest with two eggs on 18 July. Hatched, young survived at least 6 days.
1981	Common	Centre of island, north of Low Light	Nest with one egg in mid-June. Failed.
	Common	South Plateau	Nest with two eggs on 2 July. Failed.
	Common	North Plateau	Nest with one egg on 13 July. Hatched 3 Aug., fate unknown.
	Common	?	Nest with two eggs on 14 July. Hatched 5 Aug., young survived at least 9 days.

TABLE 2 Numbers of Common and Arctic Tern nests and hatching success (% eggs hatched of those laid) and overall breeding success (% young fledged from total eggs laid) on the Isle of May, 1982-7. (Information taken from Frazer 1982, Wanless 1983, 1984, 1986, Wanless & Ewins 1985, Dore & Wanless 1987).

Year	Number of nests			Hatching success %		Overall breeding success %		No. young fledged	No. young fledged per nest
	Common Tern	Arctic Tern	Total	Common Tern	Arctic Tern	Common Tern	Arctic Tern	Species combined	Species combined
1982	15	–	15	–	–	*c.*25**	–	7	0.47
1983	37	–	37	36	–	13	–	*c.*4-11	0.11—0.30
1984	37	19	56	85	87.5	High	High	*c.*50-60	0.89—1.07
1985	80	87	167	70	78	1.7	3.1	8	0.05
1986	22	128	153*	*c.*95	*c.*95	Moderate°	Moderate°	*c.*80-100	0.52—0.65
1987	76	126	202	High	High	Moderate	Moderate	*c.*100	0.50

Notes: * includes unspecified nests.
** 14 nests produced a minimum of 17 young of which at least seven fledged successfully.
° eggs and young from at least 25 nests were lost after disturbance by a helicopter.

deserted. As a result the eggs and small young from at least 25 nests were robbed by gulls; some of the larger chicks were probably also killed although some apparently moved to the Beacon colony. Young which had already fledged did not return to be fed and apart from a few birds which flew over the colony in the days immediately following the incident, adults ignored the area for the rest of the season.

In 1987 the bulk of the terns (74 Common and 123 Arctic Terns) nested within the Beacon area; also 2 pairs of Common and 2 pairs of Arctic Terns nested on North Plateau and one pair of Arctic Terns nested near St Andrew's Well. It is possible that this shift in distribution was in response to the previous year's helicopter disturbance.

In the 1930s and 1940s, the main breeding area was immediately below the North Horn, but during the1950s terns bred on the east side of Ruff Green, around St Andrew's Well, the south end of North Plateau and the slopes between Holyman's Road and the Lookout (Eggeling 1974). Recolonisation has thus occurred in all the latter areas except Ruff Green, which Eggeling considered to be suboptimal, but the traditional stronghold at North Horn has not been recolonised.

Timing of breeding

Between 1973 and 1981 most clutches were not started until July (Table 1) but breeding was generally earlier once birds started to breed in groups. One pair of Common Terns had one egg by 16 May 1982 but laying usually began at the end of May, with the main laying period from 10 to 25 June. The earliest chick hatched around 21 June and the first young fledged in the third week of July. The timing of laying was similar from year to year and was consistently later than at nearby colonies. For instance, from 1982 to 1987 the first Arctic Tern egg at Aberlady Bay was laid between 18 and 27 May and most Common and Arctic Tern clutches were initiated by the end of the first week of June (P.R. Gordon pers. comm.). Similarly the first Arctic Tern egg on the Farne Islands was found each year around 16 May and the first Common Tern egg between 17 and 22 May (National Trust Watchers pers. comm.). At the Sands of Forvie comparable dates were 22-29 May for Arctic Tern and 22-31 May for Common Tern (A.J.M. Smith pers. comm.).

In many seabird species young birds tend to breed later than older ones (e.g. Coulson & White 1958). This effect has been found in Common Terns (Hays 1978, Nisbet *et al.* 1984), but there was no significant difference in laying date amongst different age classes of Arctic Terns on the Farne Islands despite younger birds arriving consistently later (Coulson & Horobin 1976). However, the situation may well be different in a newly formed colony such as the Isle of May.

Breeding success

Four of the eight breeding attempts made between 1973 and 1981 failed soon after laying, but one pair in 1981 possibly fledged two young (Table 1). Similarly, all isolated nests failed during the period 1982-7. In the main colonies, breeding success varied greatly from year to year (Table 2). In 1985 early clutches were far more successful than late clutches: of clutches started before 25 June 81% (n = 58) of Common and 82% (n = 76) of Arctic Terns were successful, whereas comparable figures for those started on or after 25 June were 13% (n = 18) and 0% (n = 10). In 1986 and 1987 there was no such obvious seasonal decline.

Causes of failure were mostly unknown but late clutches were sometimes abandoned and predation by Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* of both eggs and chicks occurred in most years. For example, during 30 minutes on 16 July 1985, gulls made a total of 21 separate raids and at least two tern chicks were taken. Losses of both eggs and chicks tended to be greater when the weather was wet and windy; in 1987 at least 10 clutches were deserted and 69 dead chicks mostly aged 1-2 days but a few up to 14 days old,

were found between 12 and 23 July during a period of persistent wet and windy weather. In part this may have been due to chilling but several studies have shown that high winds decrease the food capture rates by adult terns and the growth rate of chicks (e.g. Dunn 1975, Taylor 1983) so food shortage may have been a contributing factor.

Except for 1985, breeding success of Common and Arctic Terns on the Isle of May was similar to that found in previous studies (Langham 1972, Coulson & Horobin 1976, Hays 1978). It was markedly higher than the breeding output from the nearby colony at Aberlady Bay where a total of no more than 11 young Common/Arctic Terns fledged between 1982 and 1987 from an annual breeding population of 68-113 pairs i.e. a productivity range of 0-0.04 young/pair (P.R. Gordon, pers. comm.). Breeding success on the Isle of May was also generally higher than at the Sands of Forvie where, except in 1987, output was less than 0.36 and 0.21 young/pair for Common and Arctic Terns respectively. The installation of an electric fence at Forvie in 1987 prevented predation by Foxes *Vulpes vulpes* and breeding success increased to 1.5 and 1.0 young/pair (details supplied by A.J.M. Smith). Terns occasionally do have breeding failures such as that observed on the Isle of May in 1985 (Bullock & Gommersall 1981).

Prey

In 1985 some observations were made on prey items brought in both for display by adults and to feed their chicks (Table 3). Sandeels *Ammodytes* sp. were the commonest prey of both tern species. *Clupeidea* (mostly herring *Clupea harengus)* were caught more frequently by Common Terns but Arctic Terns took a wider variety of items. A similar range of prey types was recorded in the less detailed observations

TABLE 3 Prey items brought in by terns on the Isle of May, 1985. (Data from Wanless & Ewins 1985).

Prey Items	Common Tern				Arctic Tern			
	Display only	Chick food	Total	Proportion (%) of all prey	Display only	Chick food	Total	Proportion (%) of all prey
Sandeels *Ammodytes* sp.	27	26	53	54	26	100	126	66
Clupeidae (mostly herring *Clupea harengus)*	9	20	29	27	10	25	35	18
Three-spined stickleback *Gasterosteus aculeatus*	–	8*	–	8	0	0	0	0
Cod *Gadus morhua*	0	0	0	0	0	1	1	0.5
Blenny sp. *Blenniidae*	1	0	1	1	0	0	0	0
Flatfish sp.	0	0	0	0	0	5	5	3
Unidentified fish	3	0	3	3	10	0	10	5
Prawn/Shrimp	1	0	1	1	0	1	1	0.5
Earthworm *Lumbricus* sp.	0	0	0	0	3	0	3	2
Unidentified	1	2	3	3	6	5	11	6
Totals	42	48	98		55	137	192	

Note: *items found lying in or near nests could not definitely be attributed to either display or chick food categories.

made in other years, but rockling *Ciliata* sp. were taken in 1983 and 1984 and herring was thought to be the main prey item in 1984.

Evidence of prospecting by other tern species

Roseate and Sandwich Terns bred on the Isle of May between *c.*1930 and 1956 (Eggeling 1960). There have been no records of the former showing interest in the island, but since 1980 Sandwich Terns have sometimes done so; a single bird was seen carrying fish on 28 July 1980 (Lack 1980), in 1985 *c.*10 birds regularly flew over the North Plateau in early June (one was seen carrying a display fish) and on 13 June some landed in the Common/Arctic colony (Wanless & Ewins 1985). On 18 June 1986 Sandwich Terns were seen displaying over South Plateau (Wanless 1986).

Discussion

In contrast to many seabird species whose numbers have increased in Scotland this century, terns are now generally less abundant than previously (Thom 1986). In a review of breeding terns in Britain and Ireland, Thomas (1982) identified some adverse factors which have had marked effects on tern numbers between 1975 and 1979. These included high tides and bad weather, human disturbance, predation and gull problems. Eggeling (1960) considered that terns abandoned the Isle of May in the 1950s because increasing numbers of Herring and Lesser Black-backed Gulls forced them to move from their favoured breeding area near the North Horn to the less favourable centre of the island. Gulls were seen eating tern eggs and chicks and, in the final years of the colony, the few terns which attempted to breed had extremely low nesting success. When terns finally deserted the island in 1958, there were *c.*3000 pairs of gulls (Eggeling 1960). Gull numbers continued to increase to *c.*17,500 pairs in 1972 (Eggeling 1974). At this time the Nature Conservancy started to cull breeding gulls on the island. Over the next ten years the gull population was reduced to 3-4000 pairs and by 1982, when Common Terns returned, gull numbers were similar to those at the time of the desertion. Thus the terns' absence from the Isle of May coincided with the period that the gull population exceeded 3-4000 pairs.

However, other factors could also be involved. For instance, young herring are often important prey for terns during the breeding season (Cramp 1985). The Firth of Forth once had a large spring-spawning herring stock which supported a considerable human fishery. Catches were good in the 1930s and early 1940s but fell rapidly from 1942 onwards, and between 1946 and 1963 virtually no adult herring were caught in the Forth (Saville 1963). Herring were apparently still scarce in 1973 at the start of a long term study of the diet of young Puffins *Fratercula arctica*, and initially no herring of the size taken by terns were recorded (Hislop & Harris 1985). They first appeared in the Puffin's diet in 1975 but it was not until 1980 that the proportion exceeded 10%. Since 1981 the proportion has ranged from 34-39% (Hislop & Harris 1985, M.P. Harris pers. comm.) and the years (1984, 1986) with the highest percentages of herring in the diet coincided with the years of highest breeding success for the terns. In the Firth of Clyde more than 50% of the annual variation in the number of Common and Arctic Terns breeding on Horse Island could be explained by changes in the abundance of post-larval and juvenile herring (Monaghan & Zonfrillo in press). Herring are obviously important in influencing the numbers of many species of seabird (e.g. Coulson & Thomas 1985, Aebischer 1986, Anker-Nilssen 1987). However, whilst there is broad agreement between the absence of terns from the Isle of May and apparently low herring stocks in the Firth of Forth, there are anomalies. First, the tern colony peaked in 1946 and 1947 just as the herring fishery collapsed. Second it persisted, albeit with reduced numbers of birds, for a further 10 years. Third, the terns' recovery lagged behind the increase in herring abundance by several years.

Another factor could have played a part in the terns' disappearance. In 1955 there was an outbreak of myxomatosis amongst the Rabbits *Oryctolagus cuniculus* on the Isle of May which was followed by marked changes in the vegetation during this and the next two seasons (Eggeling 1960). Although the main decline in tern numbers occurred before this, the long, rank vegetation was possibly unsuitable nesting habitat, particularly for Arctic Terns which prefer close-cropped turf (Cramp 1985).

No natural mammalian predators (such as rats *Rattus* spp. or Foxes) have been recorded on the Isle of May but the Lighthouse keepers used to keep pets and in the early 1970s one dog was adept at digging out and killing Puffins (M.P. Harris, pers. comm.). However, there is no mention in the Observatory records of dogs or cats affecting terns. Similarly it is hard to decide if human disturbance contributed to the terns' desertion. Since their recolonisation the terns have been protected by roping off the breeding areas. In 1983 and 1984 decoys were put out to attract prospecting birds and in 1983 sound recordings of tern vocalizations were played. Such measures have been effective in re-establishing terns in other areas where they bred formerly (Kress 1983), and may have helped here.

The 1958-79 episode was not the first case of the island being abandoned by terns. During the first half of the 19th century there was a sizeable tern colony but this was deserted between 1850 and 1920 (Eggeling 1960). In this instance there were no large gulls nesting on the island (Eggeling 1960), the Forth herring fishery was thriving (Saville 1963) and myxomatosis was unknown (Matthews 1952). The true reason(s) for the terns' desertion and recolonisation of the Isle of May is unlikely ever to be known but clearly there were several factors operating at the time which could have produced the observed changes.

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The distribution and status of Arctic and Great Skuas in Shetland 1985-86

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Totals of 1912 Arctic Skua and 5647 Great Skua Apparently Occupied Territories (AOTs) were recorded in Shetland in 1985-86, representing 61% and 76% of the British breeding population. On the Shetland Mainland Arctic Skua numbers have increased at c.4% p.a. and Great Skua numbers at c.9% p.a. since 1974-75. Human persecution and reclamation of moorlands may have affected numbers locally, but food availability was probably the main factor influencing skua numbers. Widespread breeding failure of terns in recent years has probably reduced Arctic Skua breeding output and recruitment.

Introduction

Shetland and Orkney are the traditional British strongholds of the Arctic Skua *Stercorarius skua* and the Great Skua *Catharacta skua* (Cramp & Simmons 1983, Thom 1986). Apart from early documentation of the Great Skua colonisation in the 19th century (e.g. Low 1879) no attempt was made to assess breeding numbers until the 'Operation Seafarer' surveys in 1969 and 1970 (Cramp *et al.* 1974). Unfortunately these surveys did not cover large areas of suitable skua breeding habitat inland and so the number of skuas was underestimated.

Much better coverage was achieved by the RSPB skua surveys in 1974 and 1975 (Everett 1982), but census techniques for breeding skuas have been greatly improved since then (Furness 1982). Using these refined census methods Meek *et al.* (1985) conducted a complete survey of Orkney skuas in 1982, which revealed some dramatic increases. A full survey of breeding skuas in Shetland was clearly overdue.

There has been speculation that Arctic Skua numbers in Shetland may be declining, possibly due to reduced food availability stemming from poor breeding success of Arctic Terns *Sterna paradisaea* and Kittiwakes *Rissa tridactyla* in recent years (Furness *et al.* 1986, Heubeck & Ellis 1986). Following surveys in 1985 of moorland birds in several large areas of Shetland (Peacock *et al.* 1985, Wynde & Richardson 1985), we carried out surveys in 1986 to complete the coverage for skuas. The detailed results have been presented in a full report (Ewins *et al.* 1987). This paper summarizes the results and discusses population trends and factors influencing them.

Methods

We used the 'Apparently Occupied Territory' (AOT) as the count unit, as recommended by Furness (1982). An AOT was scored for any of the following:

(i) positive signs of breeding (e.g. nest, eggs or young)
(ii) incubating adult
(iii) distracting or alarming adult(s)
(iv) pair or single bird in potential breeding habitat and apparently attached to the area

Skuas flying past, or feeding, or single birds flushed from an area and which flew out of sight were not recorded. Groups of three or more skuas

seen together regularly but which showed no sign of territorial behaviour were recorded as 'club' (non-breeding) birds. Some failed pairs may have tolerated other birds in their territories, thereby causing us to underestimate AOTs.

Between May and July 1986 the NCC Upland Bird Survey carried out detailed surveys of terrestrial birds on 32 moorland plots in Shetland, using standard techniques described by Reed *et al.* (1983). These surveys recorded the activity and position of every skua seen from the fixed transects. We translated this information into AOTs using the criteria outlined above. Counts of nests were used for Great Skuas on Noss (1983) and Hermaness (1985).

Moorland areas were divided into blocks which could be covered by one or two surveyors within a few hours. With the exception of the 1986 NCC plots the survey method involved walking transects up to a maximum of 500 m apart. Walking along ridges was an effective means of covering large areas in suitable locations. At the same time, a watch was kept for skuas flying up ahead. In addition the observer stopped at regular intervals (*c.*200-300m) and scanned the area thoroughly from a suitable vantage point. In areas where skuas were numerous, scanning took longer and more transects were walked. In such colonies it was usually necessary to stand or sit for five minutes to allow birds to settle before meaningful plots of AOTs could be made. Two people walking adjacent transects caused much confusion in high density areas, and we found that a single observer could census these areas more accurately by plotting AOT positions from various vantage points.

Surveys were completed between 25 May and 8 July, the majority during June. This six-week period was selected on the basis of available information on the timing of breeding in both species, and the timing of skua surveys elsewhere. There was no evidence that the timing of breeding in the two survey years differed markedly from normal (Ewins *et al.* 1987, Furness 1977a, Furness

TABLE 1 Shetland regional totals of skua Apparently Occupied Territories (AOT) and club birds, 1985-86. Roman numerals correspond to regions shown in Figs. 1 & 2. Proportions (%) are those in each region of the Shetland AOT total.

	Region	ARCTIC SKUA			GREAT SKUA		
		AOT *n*	AOT %	Club *n*	AOT *n*	AOT %	Club *n*
I	Unst	267	14.0	0	1257	22.3	203
II	Yell	192	10.0	33	313	5.5	38
III	Fetlar	180	9.4	0	248	4.4	35
IV	Whalsay islands	41	2.1	0	1	0	4
V	North Mainland	175	9.2	0	233	4.1	7
VI	Central Mainland & Yell Sound islands	189	9.9	10	114	2.0	4
VII	West Mainland	169	8.8	0	96	1.7	35
VIII	South Mainland & islands	326	17.0	6	792	14.0	119
IX	Fair Isle	115	6.0	20	84	1.5	54
X	Foula	164	8.6	35	2495	44.2	858
XI	Papa Stour	94	4.9	0	14	0.2	0
	TOTAL	1912		104	5647		1357

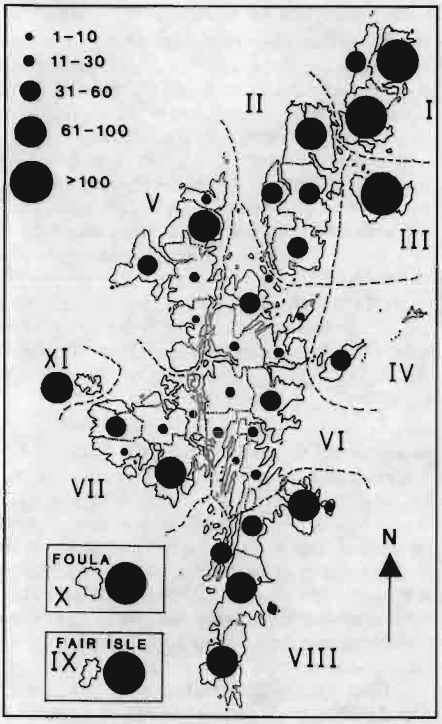

FIGURE 1 The number of Arctic Skua AOTs in different areas. Regions (Roman numerals) correspond with those in Table 1.

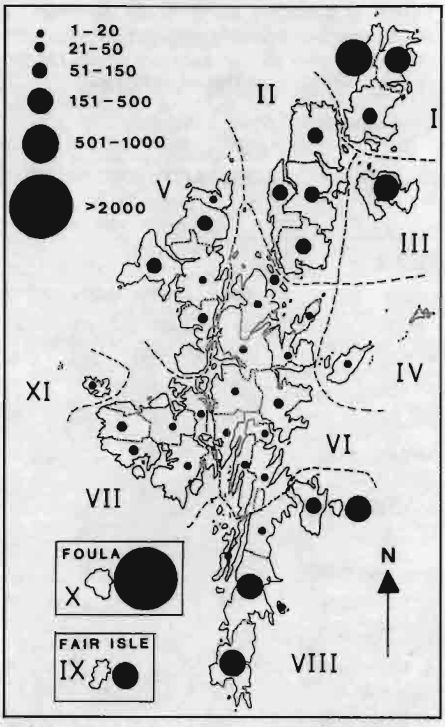

FIGURE 2 The number of Great Skua AOTs in different areas. Regions (Roman numerals) correspond with those in Table 1.

1980). Counts at either end of the day were avoided, and were not carried out in winds exceeding Beaufort force 4, or in persistent rain, very cold conditions or fog.

The largest areas were covered in 1986 by the RSPB (Bird *et al.* 1986), and the NCC. Many volunteers provided coverage of smaller areas, in conjunction with the Seabird Colony Register. Many areas of farmland and crofting in-bye were not surveyed because it was well-known that skuas were rarely seen on such habitat. Nevertheless, as a check various in-bye areas on the Mainland were observed from surrounding roads, and the anticipated absence of skuas was confirmed.

The colour phase of Arctic Skuas was determined on the basis of belly colouration i.e. dark (melanic) or pale, as recommended by P. O'Donald (in Meek *et al.* 1985).

Statistical tests are denoted by superior figures and the results are given in the Appendix.

Results

Totals, distribution and density

The surveys in 1985 and 1986 recorded 1912 Arctic Skua AOTs and 5647 Great Skua AOTs in Shetland, together with 104 club Arctic and 1357 club Great Skuas. Breeding skuas were found throughout Shetland but there was much regional variation (Table 1), which was not due simply to differences in the availability of nesting habitat. Breeding density also varied markedly between regions (see below).

Breeding Arctic and Great Skuas occurred most commonly in the northern isles (Unst, Fetlar, Yell), the south Mainland, and on some of the larger offshore islands. Arctic Skua AOTs were more regularly dispersed than Great Skua AOTs, although numbers were markedly lower in the central and east Mainland as far north as Ronas Hill (Fig. 1). Foula held nearly half of

TABLE 2 Breeding number and densities of skuas in various breeding aggregations, 1985-86. Densities refer to the area occupied by the aggregation, not of the island or region.

Location	ARCTIC SKUA		GREAT SKUA	
	AOTs	AOTs per km²	AOTs	AOTs per km²
ISLANDS				
Foula	164	133	2495	277
Fair Isle	111	85	81	45
Noss	15	150	388	242
Mousa	21	53	9	30
Hascosay	10	33	29	26
Hermaness (Unst)	11	55	819	60
MAINLAND				
North Roe	40	13	81	12
Mio Ness-Toft	31	12	10	6
Sandness Hill	20	17	31	11
W. Quarff	18	3	10	3
S. Mainland hills (N)	21	12	57	10
S. Mainland hills (S)	27	13	82	22

Shetland's Great Skuas, and Unst just less than a quarter. Great Skuas were scarce throughout the west, central, east and much of the north Mainland (Fig. 2).

Breeding densities for each species were calculated for smaller islands, or discrete breeding aggregations on larger land masses by measuring the area of a polygon drawn around the outermost AOTs of each breeding aggregation (but omitting isolated AOTs). There was considerable variation in breeding density throughout Shetland, with the highest densities of each species tending to occur on smaller islands and in the largest colonies (Table 2). This was not always the case though. A regression of Arctic Skua breeding density (Y) against the number of AOTs (X) of the adjacent Great Skua colony showed a highly significant linear relationship[1] indicating that in the vicinity of the larger Great Skua colonies, Arctic Skuas bred at higher density. This applied both to colonies on islands and on the Mainland.

Characteristics of breeding territories

Distance from the nearest sea Due to the convoluted nature of the coastline no part of Shetland is more than 5 km from the sea (Flinn 1974). Most skua AOTs were within 2 km of the sea (92% for Arctic Skua, and 97% for Great Skua). Skua concentrations on small islands will obviously tend to over-represent the categories closest to the sea. However, even when the Foula data were omitted 95% of Great Skua AOTs were within 2 km of the sea. There was a highly significant difference between the two species in the proportion of AOTs at different distances from the sea, both including[2] and excluding[3] the Foula Great Skua data. Overall, significantly more Great Skuas than Arctic Skuas bred within 1 km of the sea (79% vs. 60%)[4].

Slope Slopes were measured from 1:25,000 OS maps, and AOTs categorised by slope of habitat i.e. shallow/flat (< 10°), medium (10-30°), or steep (< 30°). On Foula all the Arctic Skuas bred on shallow/flat ground, but 36% of Great Skuas bred on slopes of medium gradient, and 9% on steep slopes. Ewins *et al.* (1986) showed than when compared with availability there was a significant tendency for Great Skuas to breed away from steeper slopes.

Elsewhere in Shetland no skua AOTs were found on 'steep' slopes, and 'medium' slopes supported only 1% of Great Skua and 0.2% of Arctic Skua AOTs (these were all close to large seabird colonies).

Habitat type Most skua AOTs occurred on peatland dominated by heather *Calluna vulgaris*. The only area in which Great Skuas were found breeding on in-bye grassland was Foula; up to 10 pairs (0.4% of the Foula population) were involved, and their breeding attempts were usually destroyed. Great Skuas preferred to nest amongst vegetation up to *c.*12 cm high, whereas Arctic Skuas often nested in shorter vegetation. Accordingly, Great Skuas were found nesting not only on peatlands dominated by heather, crowberry *Empetrum nigrum* and blaeberry/cowberry *Vaccinium myrtillus, V. vitis-idaea,* but quite often in wetter flushes with larger stands and clumps of coarse grasses and rushes *Juncus* spp. Arctic Skua AOTs were found less frequently in such poorly-drained areas with taller vegetation, and most occurred on heathery bogs, or on drier moors dominated by very short heather and various herbs and lichens, often with substantial maritime influence. Moors overlying serpentine bedrock,

those on shallow soils, and those from which the peat had previously been removed by man, were used regularly by Arctic Skuas, but not by Great Skuas, probably because the vegetation was very short.

In a few areas Arctic Skuas had established AOTs on grassland. On Foula *c.*10 Arctic Skua AOTs (6% of the Foula total) were on in-bye grassland, and most bred, apparently successfully. On Fair Isle only 2 (2%) were on previously improved grassland, although a few pairs bred in mires dominated by rough grasses, where former drainage systems had not been maintained. The application of lime and surface seeding of the Eas Brecks area by the Bird Observatory on Fair Isle in 1984 has apparently not yet affected the number of Arctic Skua AOTs there. This flat area of short heather has traditionally been one of the core breeding areas on Fair Isle. By 1986 the alien grass mix had provided a green sward, but although most of the original heather was dead (due to the liming), the leafless, shrubby remains of the plants were presumably sufficient to encourage the returning Arctic Skuas to establish AOTs here and breed. Elsewhere in Shetland Arctic Skuas bred only rarely on improved grassland, and we knew of no AOTs on areas re-seeded within the last decade.

Arctic Skua colour phases

The colour phases of birds in pairs and of single Arctic Skuas were pooled for regions with adequate sample sizes. This showed that the incidence of pale phase birds in the South Mainland, adjacent islands and Fair Isle (regions VIII and IX in Table 3) was significantly lower than found further north and west in Shetland (18.3% and 23.8% respectively)[5]. In 1986 the overall incidence of pale phase birds in Shetland was 21.6% (Table 3), which was significantly lower[6] than the 26.5% quoted for Shetland between 1943 and 1979 by Meek *et al.* (1985).

The colour phase of both members of 662 pairings was recorded in 1986 (Table 4). There was a significant difference between the proportions in the S. Mainland, adjacent islands and Fair Isle, and those elsewhere in Shetland[7]. This was consistent with the previous result, that pale phase birds were more frequent further north in the Shetland archipelago. Similarly, the overall Shetland proportions had changed significantly from those recorded between 1943 and 1979[8]. Overall, pale × pale pairings are now rarer, and melanic × melanic pairings commoner than previously (Table 4).

TABLE 3 The frequency of pale phase Arctic Skuas in 1986. Only those regions with reasonable sample sizes are detailed. N = total number of individuals whose colour phase was determined.

	Region	N	Pale phase *n*	Pale phase %
I	Unst	188	41	21.8
III	Fetlar	184	43	23.4
V	N. Mainland	47	10	21.3
VI	C. Mainland etc.	188	51	27.1
VII	W. Mainland	117	28	23.9
VIII	S. Mainland etc.	424	84	19.8
IX	Fair Isle	226	35	15.4
X	Foula	235	55	23.4
Shetland 1986		1615	349	21.6

Discussion

Comparison with the 1974-75 survey

Everett (1982) reported that the surveys in 1974 and 1975 found (estimated) at least 1631 pairs of Arctic Skua and at least 5451 pairs of Great Skua in Shetland. The surveys in 1985 and 1986 recorded 1912 Arctic Skua AOTs and 5647 Great Skua AOTs. A straightforward comparison of these totals suggests increases over the 11-year period of 17% for Arctic Skuas and 4% for Great Skuas, but such direct comparison of totals is invalid for a number of reasons:

(i) Coverage was incomplete in the 1974-75 surveys.

(ii) When examining original survey data/maps from 1974-75 we found some discrepancies between what was actually recorded, and the results summarised (and estimated) in Everett's paper.

(iii) Estimates were made for some areas and islands in 1974-75 (Everett 1982). Our experience in 1986 has shown that, at least for some areas, local ornithologists had a rather poor idea of skua breeding numbers.

TABLE 4 The colour phases of Arctic Skua pairings in Shetland in 1986. p = pale, m = melanic, N = total number of pairings. Previous Shetland data from Meek *et al.* (1985).

			PAIRINGS					
			m × m		m × p		p × p	
	Region	N	*n*	%	*n*	%	*n*	%
I	Unst	92	60	65.2	24	26.0	8	8.6
III	Fetlar	92	55	59.8	31	33.7	6	6.5
V	N. Mainland	16	11	68.8	4	25.0	1	6.3
VI	C. Mainland etc.	66	35	53.0	30	45.5	1	1.5
VII	W. Mainland	41	27	65.9	8	19.5	6	14.6
VIII	S. Mainland etc.	150	96	64.0	53	35.3	1	0.7
IX	Fair Isle	113	80	70.8	31	27.4	2	1.8
X	Foula	89	52	58.4	29	32.6	8	9.0
Shetland 1986		662	418	63.1	210	31.7	34	5.1
Shetland 1943-79		376	218	58.0	120	31.9	38	10.1

(iv) The 1974-75 surveys used less rigorous census criteria, based on the scoring of "pairs holding territory". Bradley *et al.* (1975) detailed what they regarded as a 'pair', and distinguished between territorial pairs, and non-breeding pairs, but they only regarded a single bird to be a breeder, or on territory, if it performed some distraction display. We are not aware that any consistent approach was adopted in other areas then.

In attempting to compare results from the two surveys, we considered only those areas for which coverage was known to be complete in 1974-75. Although it is not known how the 'pair' census unit of 1974-75 would have compared with an AOT unit, for the purposes of this analysis we have regarded them as comparable.

The comparisons of totals between surveys for 12 islands and six areas on the Shetland Mainland revealed that for both skua species there was a good deal of variation in the magnitude and direction of change between sites, although trends were apparent. For these sample areas (which between them held 75% of Shetland Arctic Skuas, and 93% of the Great Skuas in 1985-86), the overall weighted mean increase was 0.8% for Arctic Skuas and 15.4% for Great Skuas. These figures represent average annual increases of 0.1% for Arctic Skua, and 1.3% for Great Skua.

For Arctic Skuas, the general trend was for a slight decrease on islands, but a substantial significant increase on the Mainland. Great Skua numbers had increased significantly on islands, and even more so on the Mainland (Table 5).

Status and population trends

Using the most recently available information we have compared breeding numbers in different parts of the British range (no skuas are known to breed in Eire, N. Ireland, England or Wales). Although surveys in Orkney and Shetland have used the AOT as the count unit, counts and estimates elsewhere have usually been of pairs. We have not attempted to convert one unit to the other, and totals are given as either AOTs or pairs. Shetland supports 61% of Britain's Arctic Skuas, with most of the remainder breeding in Orkney (33%). Great Skuas are even more restricted to

Shetland, with 76% of the British population breeding there, and 22% breeding in Orkney (Table 6).

The current Scottish breeding population of *c.*3150 pairs/AOTs of Arctic Skuas represents only 0.3-3% of the estimated world population, but in terms of the population in the NE Atlantic it is an important breeding concentration; the only larger populations are in Norway (8000 pairs) and Iceland (4000 pairs, Furness 1987).

Furness (1986) estimated that *c.*12,500 pairs of Great Skuas breed currently in the northern hemisphere. He used 5000 pairs as the Shetland total; this we can now increase to 5647 AOTs, making the best current estimate 13,147 pairs/AOTs. Therefore Iceland, with *c.*5000 pairs (38%), and Scotland with *c.*7425 AOTs (56%) are the strongholds, and within Scotland, Shetland alone holds 43% of the northern hemisphere population. The 2495 AOTs on Foula account for *c.*19% of the total northern hemisphere breeding population.

In the mid-1970s the Great Skua was considered to be increasing in Scotland at an average rate of 7% p.a. (Furness 1987). A direct comparison of the 1974-75 survey total of 5970+ pairs (Everett 1982) with the 1985-86 figure (incorporating 1980s data for Orkney, Hebrides etc.) of *c.*7425 AOTs for Scotland suggests on average increase of only 2% p.a. over the last 11 years. Taking into account the improved coverage in recent surveys in the northern isles, and the small populations elsewhere, the increase of Scottish Great Skuas appears to be levelling off. A similar calculation for Scottish Arctic Skuas also reveals an average increase of 2% p.a. over the same period.

It is difficult to assess overall trends in Shetland precisely as survey methods and coverage have improved greatly in recent years, but different trends are evident on islands compared with the Mainland (Table 5). However, skua breeding numbers and their distribution have been recorded in more detail since 1960 at the major seabird stations of Fair Isle, Foula and Noss (Fig. 3). At these sites Arctic Skuas appear to have increased generally until the late 1970s then declined at varying rates into the mid-1980s. Great Skuas have increased dramatically here, though numbers on Foula appear to have stabilised or decreased

TABLE 5 Comparison of skua totals in 1974-75 (pairs) and 1985-86 (AOTs) surveys, for groups of areas where coverage was complete in both surveys.

	Number of pairs 1974-75	Number of AOTs 1985-86	Weighted mean % change	Mean % change per annum	Level of change°
ARCTIC SKUA					
Islands	1219	1115	−8.5	−0.7	ns
Mainland	201	317	+57.7	+4.2	***
Total	1420	1432	+0.8	+0.1	ns
GREAT SKUA					
Islands	4459	4905	+10.0	+0.9	**
Mainland	184	351	+145.1	+8.5	***
Total	4643	5256	+15.4	+1.3	***

Note: ° Gross changes compared statistically with the null hypothesis that no change had occurred, using G tests. ** $P<0.01$; *** $P<0.001$; ns non-significant.

TABLE 6 Most recently available counts of breeding skuas in Scotland. (SBR = Scottish Bird Report).

			ARCTIC SKUA		GREAT SKUA		
	Year	Count unit	No. AOTs	% of total	No. AOTs	% of total	Source
SHETLAND							
Foula	1986	AOT	164	5.2	2495	33.6	Ewins *et al.* (1986)
Fair Isle	1986	AOT	115	3.7	84	1.1	FIBOT (in litt.)
rest Shetland	1985-86	AOT	1633	51.8	3068	41.4	This report
ORKNEY	1982	AOT	1034	32.8	1652	22.2	Meek *et al.* (1985)
OUTER HEBRIDES							
Lewis	1982	pair	20-30	0.8	20	0.3	SBR
N Uist	1984	pair	52	1.7	0	0	SBR
Benbecula	1982	pair	6-10	0.2	0	0	SBR
St Kilda	1984	pair	0	0	37-40	0.5	SBR
N Rona	1982	pair	0	0	6	0.1	Furness (1986)
Shiants	1977	pair	0	0	2	0.03	SBR
ARGYLL ISLANDS							
Coll	1985	pair	30	1.0	0	0	SBR
Jura	1985	pair	10	0.3	0	0	SBR
Colonsay	1975	pair	1	0	0	0	Everett (1982)
SUTHERLAND							
Handa	1985	pair	35	1.1	52	0.7	SBR
Mainland	1980-85	pair	1-3	0.1	0	0	Thom (1986)
Summer Isles	1982	pair	0	0	2	0.03	Furness (1986)
Eilean Roan	1981	pair	0	0	4	0.05	SBR
CAITHNESS	1979-80	pair	40+	1.3	2	0.03	Thom (1986), Reed *et al.* (1983)
TOTAL AOTs	Minimum		3146		7424		
	Maximum		3160+		7427		

slightly since a peak in the mid-1970s. Possible explanations for some of these trends are discussed below.

Factors affecting skua numbers in Shetland

Food Supply

The distribution of both skua species corresponds fairly well to that of the main seabird colonies (see Figure 26 in Berry & Johnston 1980). The more even breeding dispersion of Arctic Skuas almost certainly reflects their greater dependence on Arctic Terns for obtaining food through kleptoparasitism. Tern colonies are quite evenly spread through Shetland (Bullock & Gomersall 1980). Although studies of Arctic Skua diet near auk breeding concentrations have found piracy of auks to be a major source of food (Furness 1980, Ewins 1986), our observations indicate that piracy of Arctic Terns is the main source of food in other areas.

During the 1970s and early 1980s sandeels (probably mostly *Ammodytes marinus*) formed the base of the Shetland seabird food pyramid (Furness 1977a, 1980, Furness & Hislop 1981, Ewins 1985, 1986, M. Heubeck pers. comm.), associated with population increases of many seabird species (M. Heubeck pers. comm.). Over the last

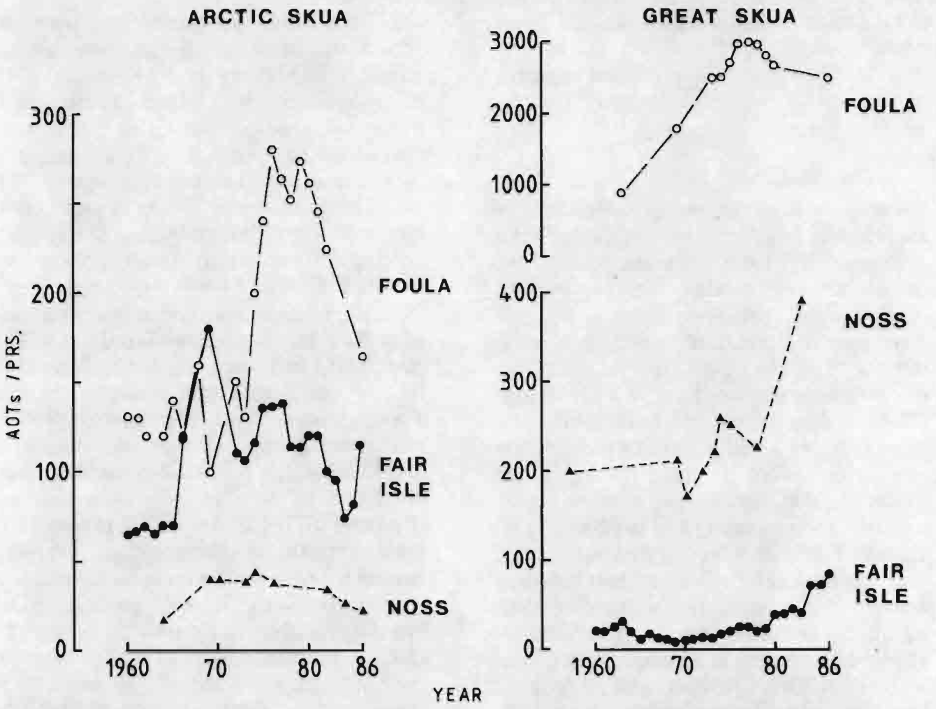

FIGURE 3 Changes in numbers of breeding Arctic and Great Skuas on three Shetland islands since 1960.

four to five years however, sandeels seem to have become less readily available, particularly to the surface feeding seabirds, and very poor breeding seasons have resulted (Heubeck & Ellis 1986, Furness *et al.* 1986, Coulson & Megson 1987). Total landings of the Shetland sandeel fishery, and the catch per unit effort, have also been declining steadily since reaching a peak in the early 1980s (Warburton 1983, R. Bailey pers. comm.).

Great Skuas are very catholic in diet and feeding habits, and although adults are opportunistic feeders they raise their young mainly on sandeels which they catch themselves. Piracy appears to be a fairly unimportant feeding method, employed when preferred feeding conditions are poor (Furness 1987). At present, Great Skuas have alternative food sources such as offal, whitefish discards, and eggs, young and adults of almost any bird species. In some parts of Shetland a few Great Skuas have specialised in taking eggs and live chicks, fledglings and adults of a variety of seabirds (Andersson 1976, Ewins 1985, Furness 1987, Harvey & Suddaby 1986, M. Heubeck pers. comm.). The forthcoming increase in the minimum mesh size for UK trawlers has raised concern that the resultant decrease in availability of whitefish discards (of suitable size to be available to Great Skuas), combined with the decline in sandeel availability closer inshore, may force Great Skuas to increase their exploitation of breeding seabirds (Furness 1987). Early suggestions that this swing has already started were evident in 1986 at a number of Kittiwake colonies (M. Heubeck & P. Harvey pers. comm.). Such a change in diet was found in Brown Skuas *Catharacta lonnbergi* nesting on Rangatira, Chatham Islands

(New Zealand): following the removal of the island's sheep, skua numbers halved and they switched from sheep carrion to heavy predation on nocturnal petrels (Young 1978).

Breeding habitat

Shortage of suitable nesting habitat largely explains the relative scarcity of Great Skuas near seabird colonies on some parts of the Mainland and on many smaller islands. Agricultural reclamation of heather moorland has invariably resulted in skuas moving to nearby nesting habitat. Such loss of nesting habitat need not in itself change skua breeding success or numbers, but there is presumably a limit beyond which nesting territories cannot decrease in size. Great Skuas could in theory breed at much higher densities than at present in most areas (excluding Foula and Noss), and we suspect that food availability rather than breeding habitat is the main factor limiting their numbers in most parts of Shetland. However, breeding success of Great Skuas is lower at high densities, and so reduced recruitment in dense colonies may be effecting a density-dependent control on numbers (Furness 1984). The breeding success of Arctic Skuas was lower at high nesting density, but not significantly so (Furness 1980).

Inter-specific competition for limited breeding habitat has occurred in some areas, and since the Great Skua arrives back on the breeding grounds first, and is a much stronger, dominant species, it is the Arctic Skua which has been forced to modify its breeding dispersion in response to increasing Great Skua numbers. On Unst, Fair Isle, and some parts of the Mainland Arctic Skuas have been forced out of certain areas, but with no significant overall decline in numbers. On Noss however, Arctic Skua numbers have dropped and the density in breeding colonies increased, largely due to displacement by Great Skuas. Arctic Skua hatching success there was 65% in 1974, compared with 80% in 1946. This was associated with an increase in breeding density from 62 to 157 pairs/km^2 over the period, and an increase in egg losses to other Arctic Skuas (Perry 1948, Kinnear 1974). Fledging success was thought to be similar in the two studies, and Great Skuas were never seen to take Arctic Skua eggs, and they seldom killed chicks (Furness 1977b).

The situation on Foula is more complex because although Arctic Skuas were similarly forced into small pockets of breeding habitat by the expanding Great Skua population, numbers actually increased at the same time as breeding density. The population increase was due to improved feeding conditions (via escalating Arctic Tern numbers and presumably greater availability of sandeels from incoming auks and Kittiwakes). Arctic Skua numbers then decreased in parallel with tern numbers (Furness 1977b, Ewins *et al.* 1986). Thus food availability rather than breeding habitat is probably the main factor influencing Arctic Skua, as well as Great Skua breeding numbers in Shetland at present. In Orkney, moorland habitats are scarcer than in Shetland, and Meek *et al.* (1985) suspected that Arctic Skua population size in some areas was actually limited by availability of breeding habitat.

Great Skua predation on Arctic Skuas

Various authors have claimed that the increases in Great Skua numbers this century have caused declines in Arctic Skua colonies in Shetland, but this has been based only on circumstantial evidence (Furness 1977b). However, Great Skua predation of Arctic Skua fledglings is now regularly observed on Noss (McKay & Crossthwaite 1985, Harvey & Suddaby 1986). In 1985 a maximum of 32 Arctic Skua chicks fledged on Noss, of which between 12 and 22 were killed subsequently by Great Skuas (a post-fledging mortality of 38-69%). Unlike the situation on Foula, this heavy Great Skua predation and 'squeezing' of Arctic Skua territories appears to be having a considerable effect, and if it continues Arctic Skuas may be unable to remain as a breeding species on the island.

Away from the smaller islands, this inter-specific predation (which is usually of fledglings but may also involve adults) may occur at low levels, but as Arctic Skuas can usually find alternative breeding habitat at a 'safer' distance from the high density Great Skua areas, they trade increased distance to food supplies against improved breeding success and adult survival.

Persecution

There is no evidence that either recruitment to, or the size of, Shetland's Arctic Skua population has been significantly affected through the limited persecution in a few areas. The much heavier, though still localised, persecution of Great Skuas (mainly of adults) has in the past been a key factor controlling numbers both locally and in Shetland as a whole. Today it is still important at the local level (Furness 1987). However, ringing recoveries indicate considerable interchange between breeding areas for both species in Shetland (though not of established breeders), and gaps created by persecution, particularly in favoured areas, are quickly filled by immigrants.

Great Skuas are prevented by man from colonising certain areas, but when this persecution is relaxed the species spreads rapidly into suitable breeding areas. On Fair Isle this has been at the expense of Arctic Skuas which have been forced to breed at higher density in adjacent areas. Therefore in such areas, human persecution of Great Skuas (on account of their alleged predation on lambs) has favoured Arctic Skuas by maintaining preferred breeding habitat free from Great Skuas.

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APPENDIX. Results of statistical tests

1. $r = 0.66$, 21d.f., $P < 0.001$; Regression equation $Y = 0.05X + 21.2$
2. $G = 272$, 3d.f., $P < 0.001$ (for G-test, see Sokal & Rohlf 1969)
3. $G = 80$, 3d.f., $P < 0.001$
4. $G = 259$, 1d.f., $P < 0.001$
5. $G = 6.94$, 1d.f., $P < 0.01$
6. $G = 8.3$, 1d.f., $P < 0.01$
7. $G = 8.82$, 2d.f., $P < 0.02$
8. $G = 9.2$, 2d.f., $P < 0.01$

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The seabirds of St Kilda, 1987

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A count of the seabirds on St Kilda in 1987 revealed that around 400,000 pairs breed within the island group. The colonies of Puffin, Gannet and Leach's Petrel are important on a world basis, while those of Fulmar, Storm Petrel, Kittiwake, Guillemot and Razorbill are important within Europe. The populations are at present healthy and the greatest future threat is considered to be the accidental introduction of Brown Rats.

Introduction

St Kilda, situated 57°49'N 08°35'W, 66km WNW of North Uist, Outer Hebrides, holds western Europe's most important seabird colony. The St Kilda group consists of one main island (Hirta), garrisoned by the Army, three outlying uninhabited islands (Dun, Soay and Boreray) and several sea stacs (Fig. 1). All the main islands and Stac an Armin and Stac Lee hold large numbers of seabirds. A full description of the geography and habitats on the islands may be found in Williamson & Boyd (1960) and Jewell *et al.* (1974).

Before the evacuation of the indigenous human population in 1930, seabirds were exploited as a source of feathers, food and fuel. Martin (1698) mentioned the large numbers of birds, and subsequent records up to 1978 have been collated by Harris & Murray (1978).

Counts of the seabirds at St Kilda are difficult because much of the coastline is inaccessible and several cliffs exceed 450 m. The first attempt at a comprehensive count of all species was made for "Operation Seafarer" (Cramp *et al.* 1974), although there had been several earlier counts of single species (e.g. Boyd 1960). Harris & Murray (1978) repeated the total colony census in 1977, and summarized all previous counts. Duncan *et al.* (1982) counted the birds on Boreray in 1980. We visited the islands in June 1987 to survey the populations for the Seabird Colony Register organised by NCC and the Seabird Group.

Methods

Most of the study was done from 12-24 June 1987. Observers were present on Hirta throughout that period, on Boreray from 13-20 June, on Dun from 15-20 June and on Stac an Armin on 16 June. Where possible, the counts were made from land. Cliff sections that were not visible from safe vantage points were counted in calm weather from 20 m and 26 m converted fishing vessels or inflatable craft. All counts were made in good visibility with no precipitation and in winds less than Force 4 (Beaufort Scale). Standard Seabird Colony Register count units (given in Results for each species) were used. Counts of Guillemots (Scientific names are given in the species summaries) and Razorbills were made between 0700 and 1500 GMT. The counts of gull territories were possibly made too late in the year, as many nests were empty and some adults might have left their territories. This might have been the consequence of a poor breeding season. Counts of Gannet nests were not attempted in 1987.

Burrow and hole nesting birds are more difficult to census. No attempt was made to count Manx Shearwaters, Storm Petrels or Leach's Petrels, but the distribution of calling birds was mapped by walking across parts of the islands between 2230 and 0230 GMT (Leaper *et al.* in press). Although close to mid-summer, most nights were overcast and dark and there was little moonlight.

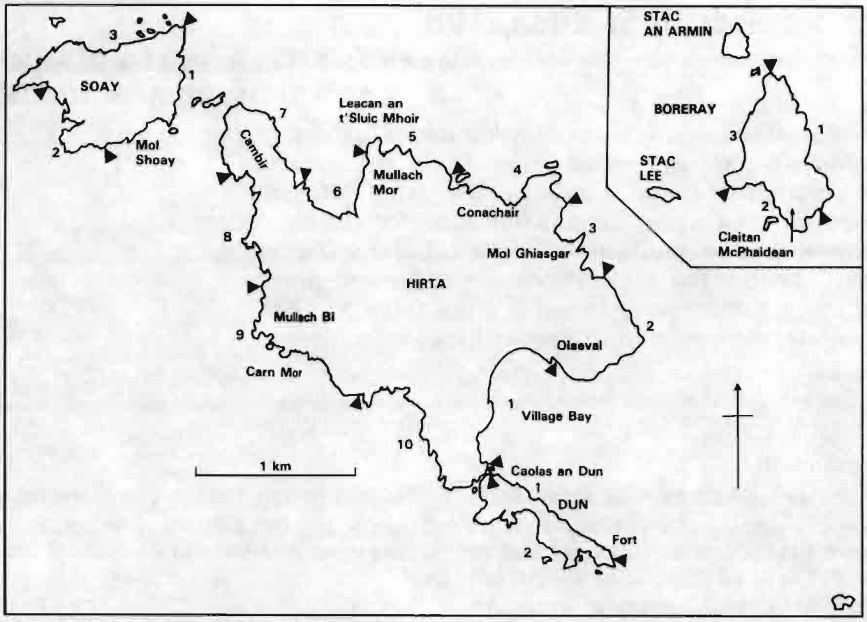

FIGURE 1 Hirta, Soay and Dun, with inset of Boreray. *Place names mentioned in text and location of sections used in Table 2 are shown.*

Calling Storm Petrels were heard on several nights from 2200 GMT. A small sample count of occupied Leach's Petrel burrows was made on Boreray both by playing a tape of the call and sniffing the entrance of suitable holes. A burrow was considered to be inhabited if a bird was heard or there was a strong smell. All Black Guillemot sightings, whether on land or at sea, were noted and the counts presented comprise the sum of the highest counts made during the period in various parts of the archipelago. This is not the ideal time or method to count Black Guillemots; better and more repeatable counts may be obtained early in the morning during April (Ewins 1985) and it is likely that our counts of this species were underestimates.

The number of occupied Puffin burrows on the south slope of Boreray (Fig. 2) was assessed using a series of 30 m^2 quadrats positioned at random in the colony. A line of bamboo canes 50 m apart was placed across the slope of the colony about 270 m above sea level. The upper and lower limits of the burrows were measured from this line. The lower limit was commonly the boundary between turf and bedrock. The colony was then mapped on squared paper with each square representing a 100 m^2 (10 m × 10 m).

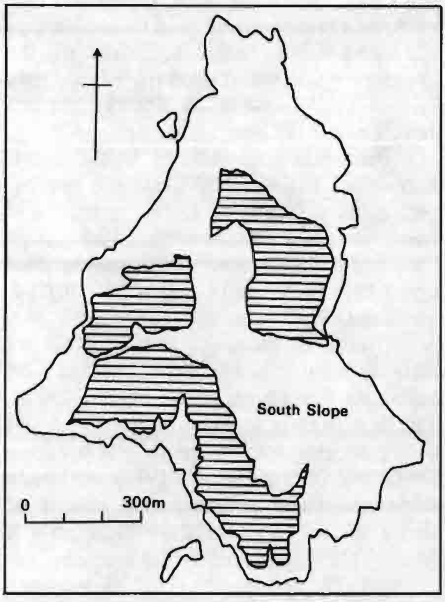

FIGURE 2 The extent of Puffin colonies on Boreray, 1987.

These squares were numbered consecutively. Within the map of the colony, 34 points were selected using a table of random numbers. These points were then located on the ground and, using a piece of string 3.08 m long for the radius, the number of occupied burrows in a circle of 30 m^2 was counted. The south slope colony was then divided into two sections, one dense, the other less so. The area of these sections was calculated from the colony map, and the mean number of occupied burrows in the 30 m^2 circles in each section was multiplied by the area of the section to produce an estimate of occupied burrows. These estimates were summed to give a total estimate for the colony.

A similar procedure has been used in previous years in the Puffin colony on Dun (Harris & Rothery in press). M.P. Harris and MLT counted occupied burrows in the random monitoring scheme on Dun on 21 and 22 May 1987. Sampling was not carried out at the other Puffin colonies (i.e. the Sunadel and west slope colonies Boreray, Soay, Hirta, Stac an Armin). The areas of Sunadel and the west slope colonies on Boreray were however assessed by eye, and an estimate for numbers of burrows in these areas was obtained from the mean burrow density of the less dense section of the south slope colony.

Results and comments on status

Fulmar *Fulmarus glacialis* A total of 62,786 apparently occupied Fulmar nest-sites was counted (Table 1). Over half the sites were on Hirta, the coastline of which was divided into 10 sections (Table 2, Fig. 1) for comparison with previous counts. The total suggests an increase of about 43% since 1977 both on Hirta and overall (Table 2). In 1977 (and on most previous occasions) counts were made in July (Harris & Murray 1978), so it is difficult to tell how much of the apparent increase might be attributable to the timing of the counts. A few Fulmars now nest inland on Hirta; this habit started around 1981 (W. Wright pers. comm.). Elsewhere there were obvious extensions in distribution when compared with that recorded on sketch maps in 1977 (S. Murray in litt.). If all of the increase was genuine, we estimate that the colony must have been increasing at a mean rate of 3.6% per annum, which is well within the capability of the species. Fisher (1952), for instance, found the colony had grown from 20,780 nests in 1939 to 38,178 nests in 1949.

Manx Shearwater *Puffinus puffinus* The only known nesting sites in the group are on Hirta, Dun and Soay; no new nesting sites were located on these islands (Soay was not visited). No birds were found during searches of Boreray by night, although not all suitable habitat was visited.

Storm Petrel *Hydrobates pelagicus* On Boreray, calling birds were found around Cleitan McPhaidein and along the main southern ridge. On Dun, the species was confined to the rocky sections of the ridge. Similar rocky cliff edges and ridges were occupied on Hirta and in addition some man-made structures were used. In general, Storm Petrels appeared to prefer structures with walls more than 1 m thick situated on dry ground. Thinner walls and structures on wet ground were not used.

Leach's Petrel *Oceanodroma leucorhoa* On Boreray, all Leach's Petrel burrows appeared to be situated within the Puffin colony on the south side up to 440 m above sea level. Burrows had not previously been found above 200 m (Duncan *et al.* 1982). A total of between four and eight nests was found in an area of 100 m^2 of the Puffin colony that was searched for nests. If this density estimate was representative of the remainder of the south slope colony (total area 79,400 m^2) then the site holds approximately 3200-6400 occupied burrows. On Hirta, Leach's Petrels were located above the cliffs of Oiseval, in the boulder field on the west of the Cambir, in Carn Mor and along the cliffs at Mullach Bi, as well as in small numbers at several locations. Calling birds were found throughout the steeper grass slopes on the north-west end of Dun. There have been no previous estimates of numbers on St Kilda.

Gannet *Sula bassana* In 1985, Murray & Wanless (1986) found 50,050 sites (Table 1). As there were no obvious changes in the extent of the colony, the species was not counted in 1987.

TABLE 1 Total numbers of birds on islands and stacs of St Kilda, 1987. aos = apparently occupied sites, p/a = presence/absence, aot = apparently occupied territories, indvs = individuals, ob = occupied burrows.

Species	Unit	Island								Total
		Hirta	Dun	Soay	Soay sound stacs	Levenish	Boreray	Stac Lee	Stac an Armin	
Fulmar	aos	35349	12018	5679	432	80	6802	39	2387	62786
Manx Shearwater	p/a	p	p	?	0	0	?	0	?	?
Storm Petrel	p/a	p	p	?	0	?	p	0	?	?
Leach's Petrel	p/a	p	p	?	0	?	p	0	?	?
Gannet (1985)	nests	0	0	0	0	0	24676	13521	11853	50050
Shag	nests	25	21	4	0	0	2	0	0	52
Great Skua	aot	44	0	8	0	0	2	0	0	54
Lesser B-b Gull	aot	129	13	0	0	0	12	0	0	154
Herring Gull	aot	14	4	0	0	3	38	0	0	59
Great B-b Gull	aot	13	12	5	0	10	15	0	1	56
Kittiwake	aos	1719	1231	1306	79	0	2923	245	326	7829
Guillemot	indvs	10465	2648	2219	1742	26	3679	490	1436	22705
Razorbill	indvs	1221	1809	263	8	9	252	15	237	3814
Black Guillemot	indvs	0	10	2	0	0	5	0	0	17
Puffin	ob	10800	41600	115000	1	0	63000	0	100	230501

TABLE 2 Counts of Fulmar sites, Kittiwake nests and individual Guillemots on St Kilda in 1959 (Boyd 1960), 1969 (J.M. Boyd *in litt.*), 1977 (Harris & Murray 1978) and 1987 (this study). The sections of Hirta, Boreray and Soay are those surveyed by Boyd (1960), see Fig. 1. Information for Fulmars in 1959 and 1969 is not available for the island sections.

Island Section	Fulmar		Kittiwake				Guillemot			
	1977	1987	1959	1969	1977	1987	1959	1969	1977	1987
Hirta 1		670	20	80	91	100	0	0	0	2
2		1284	20	50	0	0	70	110	10	10
3		8242	140	230	84	126	610	890	1205	1638
4		11199	730	1180	342	356	1970	5960	5569	4774
5		1450	70	180	11	134	670	710	815	956
6		620	120	140	146	146	100	80	439	533
7		4711	530	930	334	435	1460	1260	1137	980
8		4611	300	280	215	410	900	840	1399	957
9		1907	50	0	0	0	500	330	288	488
10		452	100	0	0	12	100	20	68	127
Glen More	few	160								
Village Bay	0	43								
Total	24809	35349	2080	3070	1223	1719	6380	10200	10930	10465
Soay 1		1935	410	470	346	462	190	280	180	433
2		2320	410	1100	270	585	1540	700	950	672
3		1424	800	850	296	259	870	650	725	1114
Total	6300	5679	1620	2420	912	1306	2600	1630	1855	2219
Boreray 1		3426	270	830	596	811	110	600	628	1005
2		964	360	410	164	422	610	860	790	1044
3		2412	1700	2520	999	1690	1450	1700	578	1630
Total	3500	6802	2330	3760	1759	2923	2170	3160	1996	3679
Dun 1			180	190	182	192	30	380	644	379
2			1140	1085	1248	1039	190	1070	3162	2269
Total	6940	12018	1320	1275	1430	1231	220	1450	3806	2648
Soay Sound Stacs	366	432	150	80	83	79	2680	1700	1855	1742
Stac Lee	50	39	200	310	158	245	200	460	300	490
Stac an Armin	2000	2387	70	570	281	326	720	1880	1313	1436
Levenish	12	80	0	0	0	0	40	70	30	26
TOTAL	43977	62786	7770	11485	5846	7829	15010	20550	22085	22705

Shag *Phalacrocorax aristotelis* The 52 Shag nests found in the group represent a minimum number breeding on the islands, as nests are difficult to locate. There were two main groups: at least 20 at the Fort on Dun and 21 in Mol Ghiasgar, Hirta. A minimum of 70 adult birds was seen at the Fort and as about 90 pairs were present here in 1984 (Moore 1984), we feel that our count may have underestimated the size of this colony. The Mol Shoay boulder field on Soay had at least four nests, but no search was made on land; 32 adults were counted standing on rocks. The two nests on Boreray are considerably less than the 50 pairs estimated to be present by Duncan *et al.* (1982). We think there is insufficient suitable habitat (e.g. large crevices and boulder fields close to the sea) on Boreray for this number of pairs. Over 200 nests were estimated on St Kilda in the mid-1970s (Harris & Murray 1978).

Great Skua *Stercorarius skua* A total of 54 apparently occupied territories was found (Table 1). Of the 44 on Hirta, 35 were in Gleann Mor and nine between Conachair and Mullach Mor. Eight birds were on Soay and there were two territories on Boreray, where no nests were found in 1977 (Harris & Murray 1978) but one pair was present in 1980 (Duncan *et al.* 1982). Twenty-five pairs were present on Hirta in 1978 (Harris & Murray 1978).

Common Gull *Larus canus* This species bred in Glenn Mor in 1986. No nests were found in 1987, but a pair showed territorial behaviour at the north-west end of the Gleann.

Lesser Black-backed Gull *Larus fuscus* A total of 154 nests or territories was found (Table 1). The largest concentration of nests was in Gleann Mor; 38 were in the steep rocky area at the north-west end, 28 on the rocks of Leacan an t-Sluic Mhoir, and a further 15 on rocks at the head of Glen Bay. Eighteen territories were found on the Cambir, and 12 and 13 territories on Boreray and Dun respectively. These figures represent apparent decreases since the mid-1970s, when there were between 160 and 240 pairs on Hirta and 30 nests on Dun (Harris & Murray 1978). It is possible however, that the count may have been after the main nesting season. Four nests were recorded on Boreray in 1980 (Duncan *et al.* 1982). Harris & Murray (1978) recorded this species on Soay but we did not see it there.

Herring Gull *Larus argentatus* The majority of the 59 apparently occupied Herring Gull territories found were on Boreray (Table 1). Harris & Murray (1978) did not record any on Boreray, but Duncan *et al.* (1982) found 49 nests in 1980. Since 1974 there has been an apparent decline from 40 to 14 pairs on Hirta and from 24 to 4 pairs on Dun. These counts may have been after the main nesting season.

Great Black-backed Gull *Larus marinus* Fifty-six pairs were located. Levenish had the densest colony with 10 pairs on its top. The 15 pairs found on Boreray represent a decrease since 1980 when around 30 pairs were estimated to be on the island (Duncan *et al.* 1982). Numbers on Hirta and Dun have declined since the mid-1970s from 31 and 40 pairs (Harris & Murray 1978) to 13 and 12 pairs respectively.

Kittiwake *Rissa tridactyla* Over one-third of the 7829 nests were on Boreray (Table 1), the main colonies being on the west side. Comparison with earlier counts (Table 2) reveals that the population is very similar to that recorded in 1959, but in the intervening period numbers apparently fluctuated.

Guillemot *Uria aalge* Although the total Guillemot population has remained constant since 1969 (Table 2), there have been changes in numbers on each of the islands. On Boreray numbers appear to have increased by around 80%, while on Dun they have declined (Table 2). The colonies at the base of Conachair are the most important, holding 46% of the total.

Razorbill *Alca torda* A total of 3814 individual Razorbills was counted throughout the islands (Table 1). The largest concentration, at the Fort on Dun, held over 1000 individuals which is similar to the number counted in 1977. Other concentrations of over 100 birds were found in the boulder fields at Mol Ghiasgar on Hirta, Mol Shoay on Soay and on the eastern shoulder of Stac an Armin. Counts have been poor in the past, so it is difficult to assess any changes.

Black Guillemot *Cepphus grylle* Seventeen birds were recorded on the water around the islands in much the same locations as before. There are two or three pairs on Caolas an Dun and two birds were observed off Gob a Ghaill, Soay.

Puffin *Fratercula arctica* There were 29,600 (s.d. 3300) occupied burrows in the part of Dun we monitored. As this section held an estimated 71% of the island's population in 1975, there may now be about 41,600 occupied burrows on Dun. There appears to have been little change since 1975 when the island was estimated to have 40,097 occupied burrows (Harris & Murray 1977).

On Boreray the denser section of the colony on the south slope had an area of 29,975 m^2. The mean density of occupied burrows was 11.7 (s.d. 7.2) per 30 m^2, giving a mean estimate of 11,637 occupied burrows for the section. The less dense section had an area of 49,450 m^2 and a mean occupied burrow density of 5.4 (s.d. 5.0) per 30 m^2, giving a mean estimate of 8819 occupied burrows. The combined area of the two other main colonies on Boreray was assessed as 238,500 m^2; using the mean density estimate for the less dense section of the south slope, these sections of the island probably hold about 42,500 occupied burrows. The total number of occupied Puffin burrows on Boreray is thus about 63,000. This figure is lower than Brooke's (1972) estimate of 77,000 occupied burrows, and Harris & Murray's (1977) estimate of 100,000 pairs.

Puffins were found under many of the cleits (stone shelters) on Stac an Armin and we estimate about 100 pairs there. The colony on Soay has long been considered the largest on St Kilda, with estimates ranging from 80,000 occupied burrows in 1971 (Brooke 1972) to 150,000 pairs in 1977 (Harris & Murray 1978). We did not survey the island but used the mean (115,000 pairs) of these estimates. The population of Hirta was not examined in 1987 but Harris & Murray (1978) estimated 8100-13,500 pairs (midpoint 10,800). These figures give a grand total for the whole group in excess of 230,000 occupied burrows.

Discussion

The importance of St Kilda

St Kilda is an internationally important site for breeding seabirds. It holds about 20% of the North Atlantic population of Gannet (Murray & Wanless 1986), around 20% of the world population of the *grabae* race of Puffin (Harris 1984) and the largest colony of Leach's Petrel in the eastern Atlantic. The Fulmar colony is the largest in Western Europe, although there are greater numbers at sites further north in the Atlantic. Over 1% of the British population of several other species breed on the islands. The Storm Petrel colony is probably the largest in Britain. Up-to-date figures for the total British populations of Guillemot, Razorbill and Kittiwake have yet to be calculated, but it is likely that the numbers of these species on St Kilda represent over 1% of the total European Community populations. These figures justify the status of St Kilda as a National Nature Reserve, its recent designation as a World Heritage Site and its proposed status as a Special Protection Area of the European Community.

Status of the seabird populations

Our counts show that most of the populations of seabirds on St Kilda are either similar to those of 10 years ago, or have increased. It is difficult to detect any trends in the Puffin population as Soay, on which

50% of the estimated total breeds, was not surveyed. The number of large gulls on the islands has declined as have some populations elsewhere in the British Isles (Lloyd & North 1987).

Conservation

The greatest potential threat to the bird populations on the islands would be the accidental introduction of rats or other ground predators. As Harris & Murray (1978) pointed out, it is surprising that rats have not already arrived on Hirta. We consider that current precautions against the introduction of rats are not adequate. The military base on Hirta is supplied by regular visits of a landing-craft that runs onto the beach in Village Bay. This landing craft visits sites in the Clyde and the Outer Hebrides to collect supplies for St Kilda, and large numbers of Brown Rats *Rattus norvegicus* have been observed on the docksides in both of these areas. We consider that urgent action should be taken to reduce the possibility of rats reaching the islands.

An oil pollution incident near the islands during the breeding season (February to October) could be very serious. A loaded tanker lost all power and drifted within 2 km of Boreray in December 1981. The rerouting of tankers that previously used the Minch to a shipping lane to the west of the Outer Hebrides, has undoubtedly increased the pollution risks to St Kilda. The threat is greater than might at first appear, as studies at sea in summer 1987 (Leaper *et al.* in press) have shown that the most important feeding area for auks during the breeding season lies near the recommended deep-water shipping lane to the east of the islands. We would not however suggest that shipping be routed through the Minch, as this area holds important concentrations of birds throughout the year (Benn *et al.* in press), whereas the waters to the west of the Outer Hebrides are used by large numbers of auks and other vulnerable seabirds only during the breeding season.

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Puffins on Dun **K. Taylor**

Greenland White-fronted Geese in Caithness

S. LAYBOURNE AND A.D. FOX

Numbers of Greenland White-fronted Geese wintering in Caithness have declined from over 730 in the 1970s to c.220 in spring 1987, although numbers in the county remain of international importance. While the reasons for the decline remain unknown, continued loss of traditional peatland habitat has led to increasing numbers resorting to agricultural land.

Introduction

The world population of Greenland White-fronted Geese *Anser albifrons flavirostris* breeds in west Greenland and winters exclusively in Ireland, northwest Scotland and two sites in Wales. Ruttledge & Ogilvie (1979) estimated a total of 14,300-16,600 birds in the late 1970s, which was a marked decline from the 17,500-23,000 estimated in the 1950s. The first simultaneous census of mainland Britain, in November 1982, gave a total of 7,189 (Stroud 1984a). This had risen to 10,858 by November 1986 (Stroud 1986), probably due to protection throughout much of its summer and winter range and a very good breeding season in 1985. Simultaneous counts on mainland Britain and in Ireland (organised by the Department of Tourism, Fisheries and Forestry, Dublin) gave a grand total of 22,353 Greenland Whitefronts in November 1985 (Norriss & Wilson 1986).

While an increase in the population is encouraging, results giving only totals mask the continued decline of many of the smaller, remote flocks in Scotland and Ireland away from the main wintering grounds of Wexford Slobs in south-east Ireland and Islay in the Inner Hebrides.

The peatland roost sites of Greenland White-fronted Geese in Scotland and Ireland are now under threat from commercial peat-cutting and forestry activities. The internationally important numbers of Whitefronts in Caithness have fluctuated over the years and little was known of their flock structure, feeding or roosting sites. For this reason, efforts have been made since the late 1970s to obtain accurate counts of Whitefronts in Caithness and to examine the relationships between their feeding areas and roost sites. In this paper, we document results of the counts in Caithness over this period, and of a more intensive study carried out in March 1985.

Methods

Regular counts of White-fronted Geese have been carried out in Caithness over a number of years as part of the annual grey goose census organised by the Wildfowl Trust. However, no attempt had been made to count at all the known wintering sites of Greenland Whitefronts, or to arrange simultaneous counts of geese at these sites. Since 1981/82, SL has carried out detailed counts of Whitefronts to coincide with international counts throughout Britain and Ireland. All the Caithness resorts have been visited during a single day in the autumn and spring census periods (mid-November and late March/early April respectively), and additional counts have been made through the winter.

To eliminate the possibilities of interchange between flocks during his day-long counts, intensive observations were carried out by a team of 12 observers using four cars in Caithness between 24 March and 3 April

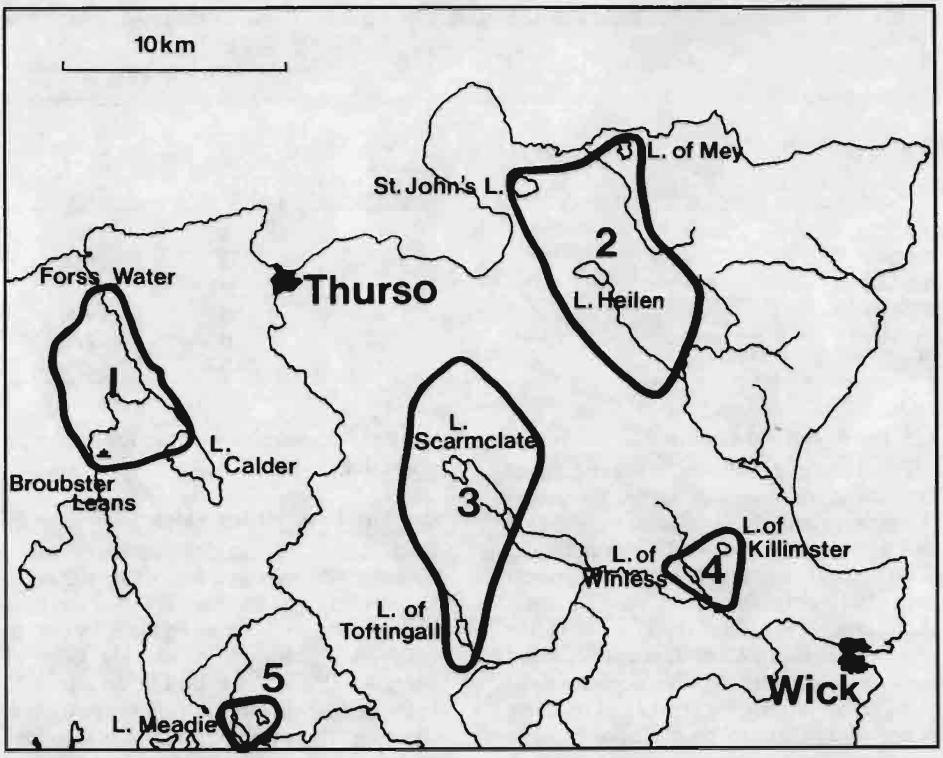

FIGURE 1. *Map of Caithness showing geographical areas described in the analysis of Greenland White-fronted Goose use.*

1985 (Laybourne & Fox 1985). All areas ever known to attract Greenland Whitefronts for feeding or roosting were visited at least once during the survey. All Whitefront observations were recorded and plotted with details of land-use on 1:10,000 OS maps. Simultaneous counts of all areas found to hold geese during the early part of the census were carried out on 29 and 30 March.

In addition, a review of earlier counts was undertaken, using the National Wildfowl Count database and the literature sources referred to below.

Results

Maximum counts of Greenland White-fronted Geese during November gave totals for the county ranging from 278-735 between 1970 and 1980; more than 350 were present in all years except 1970. However, some counts are maximum, unco-ordinated counts from different sites and it is difficult to assess the reliability of these totals. There seems little doubt that throughout that decade there were at least 350-400 birds present, but the absolute numbers are unknown.

Since 1981, better count coverage has been possible with all sites visited during one day. The spring count totals are shown in Table 1. These improved counting techniques have shown that there are five main groups of White-fronted Geese in Caithness (see Fig. 1 for locations).

TABLE 1 Co-ordinated spring counts of Greenland White-fronted Geese in Caithness, 1981/82 – 1986/87.

Year	Lochs Calder and Broubster	Lochs Scarmclate Watten & Winless	Loch Heilen	Other Areas	Total Spring Count
1981/82	180	77	42	0	299
1982/83	246	77	160	152	635
1983/84	140	67	120	41	368
1984/85	124	233	2	60	419
1985/86	157	54	25	0	226
1986/87	80	0	144	0	224

1. The Westfield Group

This discrete group utilises agricultural land to the south-west of Thurso. Numbers throughout any one season are consistent and up to nine colour-ringed birds caught in Greenland during 1979 have been present here but not elsewhere in Caithness (Labourne 1987). The flock feeds in the valley of the Forss Water in cereal fields and permanent pasture on the deeper fertile soils, rough pasture higher up and on some peaty accumulations on the hilltops. The geese start feeding on spilled grain on stubble, but transfer to pasture later in the season when this source of food is exhausted. They regularly roost on Broubster Leans, a complex valley bog with a range of wetland communities and open water, but will resort to Loch Calder to the east if disturbed.

Three hundred and seventy birds were counted in this group during 1978/79, but this had fallen to 220-250 by 1979/80, and to 80 in March 1986 (Table 1). There has been much reclamation of rough pasture and fields have been drained and reseeded and are no longer used by geese. In spring, Greylag Geese *Anser anser* are increasingly using the areas of wetter rough pasture preferred by the Whitefronts. The reseeded leys are also very attractive to Greylags and licences have been granted to disturb them. This undoubtedly also caused disturbance to Whitefronts at a time when the geese are rapidly accumulating reserves for the spring migration.

2. The Loch Heilen Flock

Loch Heilen is set in rich pasture on windblown sandy soils and is used by the geese for roosting and feeding. This flock ranges widely north to fields along the coastal strip between St John's Loch and the Loch of Mey, which the flock uses as an alternate roost despite disturbance there from duck shooting. These birds are known also to feed on the in-bye fields of old crofts in the extensive peatlands to the south and east of Loch Heilen. In the early 1970s, this group regularly flighted to and from Loch Meadie which was being used as an alternative roost, although they no longer do so. There may be some interchange between this flock and that of the peatlands considered below, but two colour-ringed birds consistently reported from the Heilen flock have not been seen in other flocks so any interchange is probably minimal.

In 1979/80, 190 Whitefronts were present in the Heilen area, but just over 144 were counted in 1986/87. There are several hundred Greylags near the loch in spring and autumn, and licences have been granted to disturb them. Many of the Whitefront feeding areas are remote, and there is an abundance of alternative feeding sites in the vicinity, so it is likely that these birds are not too disturbed.

3. Central Group

Loch Scarmclate is an important site for wintering wildfowl and the gently sloping areas of reseeded and rough pasture by the loch are much frequented by Greylag and White-fronted Geese. Whitefront numbers have remained between 100 and 150 between 1979/80 and 1985/86; they use stubble fields north of Scarmclate early in the season and move to permanent pasture later. In the past, these geese have been seen flighting between here and Loch Heilen at dusk, but in recent years have only used Loch Scarmclate. The Whitefronts also feed south and east to Loch Watten and further south to the marginal reclaimed land on the edge of the extensive areas of flow country further south to Loch of Toftingall, where birds are known to have roosted in the past. During the winters of 1985/86 and 1986/87, this flock apparently deserted the immediate area of Loch Scarmclate but may have joined those roosting at Loch Heilen or Loch Meadie.

Anglers use Loch Scarmclate, and some adjacent areas have applied for licences to shoot Greylags. There has been relatively little agricultural change in this area, although the blanket mire about Loch of Toftingall has been afforested in recent years.

4. Moss of Killimster Flock

The Moss of Killimster is an area of species-rich lowland blanket mire with well-developed surface patterning, which is the traditional habitat of the Greenland Whitefront. This area with the adjacent swampy vegetation of Loch of Winless, wet meadows and reseeded fields supports a flock of *c.*40 geese which seems discrete. Examination of past counts from this area also suggests that 40-50 birds have been consistently present here. Geese have been seen feeding on stubble fields north of the loch and a group of *c.*40 feeding on pasture adjacent to Loch of Wester was presumably this group.

The presence of this flock was confirmed in 1984/85. It was previously assumed to be part of the Loch Heilen flock to the north. However, the presence of *c.*40 birds in the area since the early 1970s suggests this small group may have been in this part of Caithness for some time. Disturbance to the Killimster area is slight, with safe and quiet areas available nearby. The Loch of Wester area is subject to goose shooting to disturb Greylags and a trackway manufacturing lengths of continuously welded pipeline also detracts from the site. Upstream of the Loch of Wester, there has been extensive afforestation of lowland blanket mire which was probably important for the geese in the past.

5. South-western Flock

The Loch More area of Caithness has held Whitefronts since the end of the last century, when Harvie-Brown & Buckley (1887) found the keeper at Strathmore bred pinioned birds descended from slightly wounded geese shot on the peatlands about the Lodge. Loch Meadie and Loch a'Cherigal were roost sites throughout the 1970s since twice-daily flights occurred between here and Loch Heilen. This roost flight ceased as winter progressed and has not been noted with any regularity in recent years. A flock of 60 flew in to roost on 27 March 1985, and birds were heard on other evenings at this site, but where these birds were feeding remains unknown. The up-rooted stems of cotton grass *Eriophorum angustifolium* with their bases eaten were found at a peatland flow site in 1985/86 and 1986/87, proving the birds were using the blanket mire regularly if only for night-time roost feeding.

Discussion

The northern and western distribution of wintering Greenland White-fronted Geese in Britain is associated with that of oceanic blanket bog with "pool and hummock" surface topography. Here, the over-wintering geese eat the subterranean parts of the

white-beaked sedge *Rhynchospora alba* and cotton grass which are common in such mires. There are few ground frosts to deny the geese this food and the soft *Sphagnum* carpets where the plants grow remain accessible in most winters.

The continuing loss of traditional peatland wintering habitat is a major cause for concern. With improving drainage techniques and ever more efficient machinery, the wetter, more heavily surface-patterned mires are now under as much threat for peat extraction, agricultural improvement and afforestation as the most easily drained bogs. Ruttledge & Ogilvie (1979) ascribed the decline of Greenland Whitefronts at 35% of sites and the desertion of 61% of sites to these factors. The destruction of Irish bogs continues (Ryan & Cross 1984) and drainage of the most important roost site in Britain for these geese began at Eilean na Muich Dubh SSSI (Duich Moss) on Islay in August 1985, although this has since ceased (see Stroud 1984b, 1985). At the time of writing, the flocks of Greenland Whitefronts at Loch Shiel (Lochaber), Moine Mhor (Argyll), Loch Sgoud (Wester Ross) and some of the Caithness group are the only ones using traditional boglands for substantial daytime feeding. The numbers involved amount to less than 0.1% of the total Scottish wintering population. With the exception of the Brent Goose *Branta bernicla* feeding on intertidal vegetation, the mire-feeding Greenland Whitefront now represents the last European goose species still wintering on natural (rather than agricultural or semi-natural) habitat. With such small numbers involved and the continued loss of this specialised habitat, the future for Greenland White-fronted Geese feeding on traditional areas looks uncertain.

In the past, Greenland Whitefronts have shown an inability to utilise alternative habitats when bog feeding has been denied them. The most dramatic example of this was the extinction of 600 birds in central Wales due to the hard weather of 1962/63 (Fox & Stroud 1986). However, at many wintering sites, flocks now feed on farmland, particularly the poorer, wetter pasture, eating the roots and tubers of plants such as buttercups *Ranunculus bulbosus, R. flammula,* marsh arrow grass *Triglochin palustre* and lady's smock *Cardamine pratensis* (D.A. Stroud pers. comm.). Even in these situations, the geese still often use peatlands as roost sites and may feed on *Eriophorum* during the night (as at Duich Moss, Stroud 1984b, 1985). While geese in Caithness are increasingly using agricultural areas, their roosting sites remain lochs and peatland lochans which are also used to a greater or lesser extent as feeding areas. The peatland roost sites are now under threat from commercial peat cutting and afforestation (Stroud *et al.* 1987). Although at present there are few conflicts between Greenland Whitefronts and agriculture, it is clear that continued loss of peatland habitat will result in an increasing proportion of the population resorting to farmland.

White-fronted Geese were described as "not an uncommon species in Caithness" at the end of the last century (Harvie-Brown & Buckley 1887), but Berry (1939) states "none of the observers in this area makes any mention of the White-fronted Goose, nor was the writer able to hear of any wintering in Caithness in 1931-32". Little is known of their subsequent status until the early 1960s when they were confirmed as belonging to the Greenland race. Atkinson-Willes (1963) showed peak counts of 10-100 for Caithness. Perhaps as many as 730 Whitefronts were present in the 1970s, but the county total, which numbered 635 in spring 1983, has since declined to 224 in spring 1987. Even allowing for this decline, the county total is still of national importance.

The decline of the Caithness Whitefront flocks over recent years gives cause for concern. Although most of their roosting sites are now protected as SSSIs, their feeding areas vary from year to year (depending on land-use management). The relationship between the geese and the peatlands is poorly understood and needs

further study before this feeding habit is lost forever. On agricultural land, protection from disturbance in late spring when they are feeding prior to leaving for the breeding grounds would seem advantageous. The provision of refuge areas would also reduce the current high level of disturbance on much of the farmland. Such refuges, managed specifically for Barnacle Geese *Branta leucopsis* have been very successful at Caerlaverock on the Solway (Owen *et al.* 1987) and at Loch Gruinart on Islay, where the less intensively managed grasslands have also proved effective as feeding refuges for Greenland Whitefronts.

Conservation, however, is concerned with the maintenance of regional natural diversity and cannot be restricted to the establishment of nature reserves. The Greenland White-fronted Goose has a long association with Caithness and now poses a unique conservation problem; continued monitoring of the population and protection of the remaining peatlands is required to protect the birds for the future.

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Mute Swans in Ayrshire

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The results of a study on Mute Swans in Ayrshire in 1984-86 are presented and compared with the results of censuses in 1955 and 1983. The total population in the county has declined by 59% since 1955. Possible reasons for this decline are discussed.

Introduction

Concern was expressed during the 1970s about declines in Mute Swan *Cygnus olor* populations in certain areas of England, with lead poisoning at least partly implicated as a cause of this decline (NCC 1981). Subjective impressions suggested that Mute Swans in Ayrshire were also declining at this time. In 1978 the BTO organised a national census based on 10 km squares selected at random (Ogilvie 1981) but, because of the nature of the census, accurate interpretation of the results for Ayrshire was difficult. Continuing concern led to a further complete national census in 1983 (Brown & Brown 1985, Ogilvie 1986). The results confirmed that the population in Ayrshire had declined since the last complete census in 1955 and that breeding success was very poor. This prompted an attempt to survey Mute Swans in detail in Ayrshire in 1984-86 and the results of this study are presented here.

Methods

The study area comprised the old county of Ayrshire. During the years 1984-86 all known breeding sites were visited regularly throughout the year. In addition, all other apparently suitable sites were visited several times annually. As some pairs move their young from the nesting site soon after hatching, regular visits allowed these movements to be monitored. To avoid undue disturbance, no attempt was made to determine clutch size but visits were timed to count the number of young which hatched and regular visits were made subsequently to assess the survival of cygnets. Counts of non-breeding flocks were made in April when this population is at its most sedentary (Ogilvie 1981).

Statistical results indicated by superior figures are given in the Appendix.

Results

Table 1 summarises the results for 1955 and 1983-86. The number of territorial pairs during 1983-86 remained fairly stable, averaging 24. Although several traditional sites were unoccupied in 1985, five sub-adult pairs held new territories in 1986. Over the four-year period, an average of 61.5% of breeding pairs hatched young. Of 25 breeding attempts which failed during incubation, there was strong circumstantial evidence that egg collecting accounted for 15 (60%) of these failures. Of the remainder, one nest was flooded, six failed to hatch after prolonged incubation and were presumed infertile whilst three failed for unknown reasons. After 22 failures of first clutches, 10 second attempts were made of which seven hatched young. One pair in 1986 had two clutches robbed but reared four young from a third attempt. The number of young hatched per breeding pair averaged 2.3 over 1983-86 with 1.6 young fledged per breeding pair. Overall cygnet survival was 71.4%, with death due to natural causes thought to account for most of the cygnets lost.

TABLE 1 Summary of Mute Swan breeding data for Ayrshire, 1955 and 1983-86.

	1955	1983*	1984	1985	1986	Average 1983-86
No. of territorial pairs	32	23	26	21	25	24
No. of breeding pairs	29	18	22	20	19	20
No. of pairs hatching young	22	10	16	13	10	12
Breeding pairs (%) hatching young	75.9	55.5	72.7	65.0	52.6	61.5
No. of young hatched	103	23	70	49	40	45
No. of young hatched/breeding pair	3.6	1.3	3.2	2.5	2.1	2.3
No. of young fledged	—	11	52	37	30	32
No. of young fledged/breeding pair	—	0.6	2.4	1.9	1.6	1.6
Survival (%) of hatched young	—	47.8	74.3	75.5	75.0	71.4

* The figures for 1983 have been adjusted slightly from those of the national census in light of data obtained subsequently.

Table 2 summarises the numbers of territorial and non-breeding birds present in 1955 and 1983-86. The non-breeding population averaged 42% of the total population in 1983-86 compared with 70% in 1955.

The ratio of non-breeders to territorial birds in 1955 was very significantly greater[1] in 1955 than that in any year of the survey. Differences between years during the study were small, although the ratio of non-breeders in 1984 was significantly lower[2] than that in 1985. The only large flock occurred on the River Ayr with the remainder scattered at other, mainly coastal sites. The highest April count on the River Ayr during 1983-86 was 13 in 1986 whereas in 1955 the count was 68.

Discussion

The 1955 national census (Rawcliffe 1958) provides the only baseline against which comparisons may be made. The total Ayrshire population was estimated then at 213, with 64 territorial birds and 149 non-breeders. The counts of non-breeding birds were made during May and June and may therefore have been overestimates. In

TABLE 2 Mute Swan population in Ayrshire, 1955 and 1983-86.

Status	1955	1983	1984	1985	1986	Average 1983-86
Territorial population	64	47	53	43	51	49
Non-breeding population	149	38	26	48	45	39
Non-breeders as % of total	70	45	33	53	47	—
TOTAL POPULATION	213	85	79	91	96	88

Notes: Territorial population includes a single territorial male for 1983-86.

1983-86 the total population averaged 88, revealing an overall decline of 58.7% since 1955. This was mainly due to a 74% drop in the number of non-breeders. The average territorial population over 1983-86 decreased by 23%. The increase in the numbers of non-breeders in 1985 and 1986 may have been partly due to improved breeding success in the preceding seasons.

The 1978 Mute Swan census showed a decline in the national population of 15% since the last complete census in 1955 (Ogilvie 1981), but by 1983 the population had recovered to a level only 8% below that of 1955 (Ogilvie 1986). In Scotland in 1983 swan numbers were only 3.6% lower than in 1955 (Brown & Brown 1985), but there was considerable variation between regions. Increases of up to 111.1% were recorded in Orkney and the north-east but there were declines of up to 94% in other counties.

It is difficult to find any single explanation for the decline in Mute Swans in Ayrshire. Former breeding sites which are no longer occupied still appear suitable and unpolluted, and few appear to be subject to excessive human disturbance. Overall breeding success during 1983-86 was poor, with only 1.6 young fledged per breeding pair. This compares with 2.8 in Lothian (Brown & Brown 1984), 2.2 in Oxford (Bacon 1980) and 1.5 in the Uists (Spray 1981). As it is mainly locally bred cygnets which maintain both the non-breeding population and, subsequently, the breeding population, it seems likely that poor breeding success may be a major factor preventing an increase in numbers. The most consistently successful pairs used either inaccessible nest sites or sites where human interference was minimal. It is disheartening the egg collecting is still a major problem in the county, particularly as losses at this stage are more damaging than losses of hatched young.

Poor weather during the breeding season may reduce breeding performance. In the cold, wet spring of 1983, only 55.5% of breeding pairs hatched young, with 0.6 young fledged per breeding pair. In the warm and dry spring of 1984, 72.7% of breeding pairs hatched young, with 2.4 young fledged per breeding pair. The highest mortality of young occurred in the first few weeks after hatching (cf. Eltringham 1966). However, the 50% overall mortality quoted by Eltringham is considerably higher than the 28.6% recorded in this study.

Although lead poisoning is an important cause of Mute Swan deaths in certain parts of Britain, Brown & Brown (1984) found no evidence that it was a major problem in Lothian. Insufficient data are available to allow comment on the situation in Ayrshire, but it is likely to be similar to Lothian. Coarse angling is not as popular here as in many parts of England.

Data on Mute Swan mortality are difficult to obtain; the majority of cygnets lost were thought to have died of natural causes, but in 1984 three were killed by a car ferry at Largs and two were shot near Irvine. Analysis of ringing data has shown that about 50% of Mute Swan deaths are due to collisions with overhead power lines (Ogilvie 1967). In Ayrshire at least seven swans are known to have died in this way in 1984. Other factors such as starvation, hard winters and predation by Fox *Vulpes vulpes* and Mink *Lutreola lutreola* may also be involved.

The decline in the Ayrshire population since 1955 is probably due to a combination of factors, of which human interference is the most important. Because British Mute Swans are largely sedentary, recovery must come mainly from the local production of young rather than through immigration from unaffected areas. Brown & Brown (1984) felt it unlikely that the Lothian breeding population would return to the levels of the 1950s in the forseeable future. With a relatively small breeding population it seems likely that the same conclusion is applicable to Ayrshire.

Acknowledgments

I should like to thank A.W. Brown and M.A. Ogilvie for supplying the original data from the

surveys in 1955 and 1983. I also wish to thank the many observers who supplied casual records and R.H. Hogg for supplying the records submitted to the Ayrshire Bird Report. A.W. Brown and G.S. Riddle gave constructive criticism of an earlier draft.

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APPENDIX. Results of statistical tests.

1. 1983, $X^2 = 15.5$, $P < 0.001$; 1984, $X^2 = 31.4$, $P < 0.001$; 1985, $X^2 = 7.54$, $P < 0.01$; 1986, $X^2 = 14.11$, $P < 0.001$.

2. $X^2 = 5.99$, $P < 0.02$.

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The distribution and abundance of the Barn Owl *Tyto alba* in south-west Scotland

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Breeding Barn Owls were recorded in 88% of 83 10 km squares examined in south-west Scotland between 1981 and 1986. The total breeding population for the area was estimated to be 139 pairs in 1985 (a poor vole year) and 321 pairs in 1981 (a good vole year).

Introduction

Throughout most of Britain and much of continental Europe Barn Owl *Tyto alba* numbers have declined considerably in recent years (e.g. Bunn *et al.* 1982). The decrease has been attributed mainly to changes in farming practice affecting the availability both of suitable hunting areas and of nest sites. In Scotland Barn Owls have been recorded breeding as far north as Sutherland but the main concentration is in the south-west (Thom 1985). The BTO Breeding Atlas (Sharrock 1976) recorded breeding in most of the 10 km squares of this area but did not estimate the density or number of pairs. This paper provides up-to-date information on the distribution of the Barn Owl in south-west Scotland and estimates density and population size.

Methods

Between 1981 and 1986, 83 10 km squares in south-west Scotland were examined. The time required to search each, especially those where Barn Owl numbers were low, was considerable and it was not possible to visit all squares every year. Each was visited at least once during the study and most were visited in at least four of the six years. Evidence of breeding was accepted only when one of the observers had seen a Barn Owl clutch or brood. No use was made of any unsubstantiated information.

Barn Owl numbers are known to fluctuate in response to changes in the abundance of their prey (Cramp 1985). To include such variation in the estimates of density, the abundance of the owls' main prey, the Short-tailed Vole *Microtus agrestis* was monitored each year by trapping in early spring (March/April) when the owls started to lay. Voles were trapped at six sites each year in young conifer plantations. At each site 25 trapping stations were used with two treadle-operated breakback traps at each set for five consecutive nights. The cumulative catch averaged over the trapping sites was used as the year index of vole abundance. Using the same method Charles (1981) has shown that changes in vole abundance occur synchronously over south-west Scotland.

Owl densities were then examined in the years of highest and lowest vole numbers recorded during the study. Estimates of density were obtained from a sample of 22 10 km squares selected throughout the area from New Galloway to Newcastleton, which included all habitats and altitudes in the area. The sample represented 36% of the total available land area. The number of Barn Owl pairs breeding in each square was counted in 1981, 1983 and 1985.

The method of locating breeding pairs involved searching all man-made structures such as farm buildings and disused and derelict buildings. It is unlikely that pairs nesting in such sites were overlooked. Pairs nesting in trees were more difficult to find. Extensive searches were made in winter to

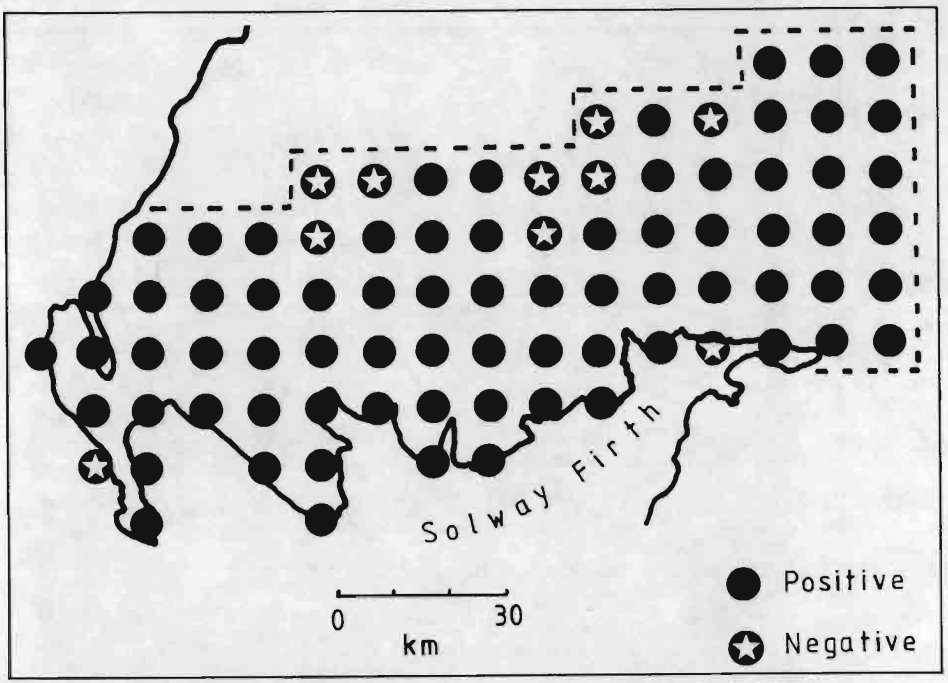

FIGURE 1 The distribution of breeding Barn Owls in south-west Scotland, 1981-1986.

locate suitable nest trees and in summer for occupied sites, concentrating in particular on isolated trees and those along hedges and woodland edges. Sites used by breeding Barn Owls were conspicuous, even in winter, from pellet debris at the base of the tree.

Results

Breeding Barn Owls were recorded in 88% of the 83 squares examined (Fig. 1). Of the 10 squares in which none was found, eight were in mainly upland areas where most of the land was above 1000' (305 m) and so beyond the normal altitudinal limit of the species. The remaining two were on the coast. One of these, south of Portpatrick on the west of the area, included stretches of sea cliff which could not be searched exhaustively and nesting pairs may have been missed there. The other was a narrow strip on the north Solway shore west of Annan.

The mean density of breeding Barn Owls in 1981, the year of highest vole abundance (index = 44), was 5.1 pairs per 10 km square. In 1985, the year with the lowest vole abundance (index = 1), the mean density of owls was 2.2 pairs per 10 km square (Table 1, Fig. 2). However, high confidence intervals were associated with these estimates due to the great variation in the number of pairs (0-10) in the squares sampled. We can be 95% certain that the true mean density lay between 3.72 and 6.48

TABLE 1 Estimates of the mean density (pairs per 10 km^2) and total number of breeding pairs of Barn Owls in south-west Scotland. 95% confidence limits are shown in parentheses.

	1981	1983	1985
Density	5.1 (1.38)	2.5 (0.82)	2.2 (0.65)
No. pairs	321 (87)	156 (52)	139 (41)

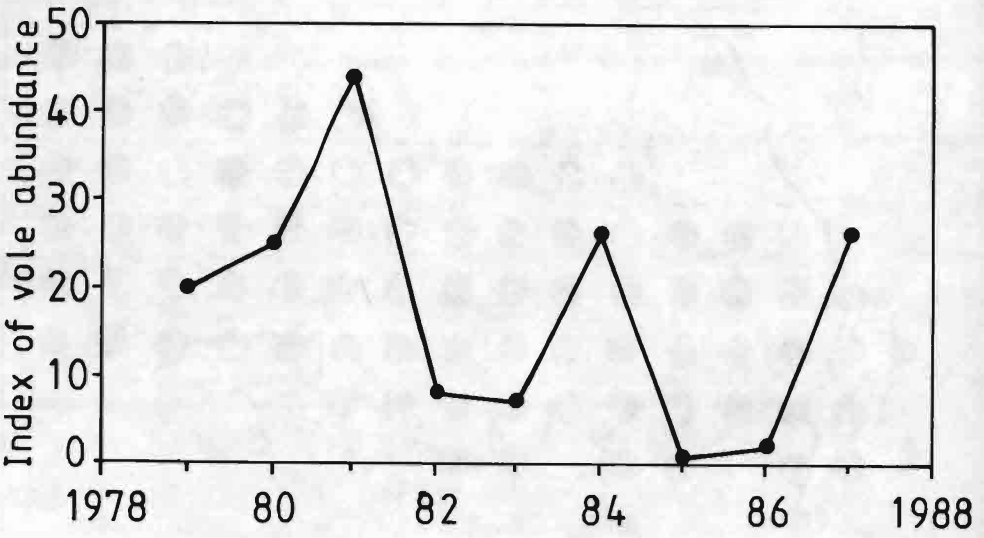

FIGURE 2 Yearly changes in the abundance of the Short-tailed Vole.

breeding pairs of owls per 10 km square in 1981 and between 1.55 and 2.88 pairs in 1985.

It is possible to estimate the size of the south-west Scotland breeding population from these values. The total land surface area was approximately 6300 km^2. Thus the estimated mean number in 1981 was 321 pairs and in 1985 was 139 pairs (Table 1).

Discussion

This study has shown that the Barn Owl still breeds in most of south-west Scotland except at higher altitudes.

Because of changes in the Barn Owl population and the percentage breeding, the estimated density of breeding pairs varied more than twofold over a four-year period associated with changes in the abundance of Short-tailed Voles. A detailed analysis of Barn Owl population dynamics will be published elsewhere but it is important to state here that no factor other than changes in vole abundance could have accounted for these large short-term changes in the owl population. There were no significant changes in land use during the period. Some nest sites were lost but in 1985 when owl numbers were lowest, available nest sites considerably exceeded the number of breeding pairs. The winter of 1981-82 was quite severe but the slightly higher than average mortality associated with it was not enough to account for the 1985 population level. The variation stresses the need to take prey abundance into account when attempting to assess long-term changes in Barn Owl populations.

Also, even when considering only a single year and with a very large sample size (36% of the total area) the confidence intervals associated with the density estimates were large (+/− 27% of the mean). This means that even if the prey supply was constant it would be impossible to be sure the

population had definitely increased or decreased unless the change in either direction exceeded 27% of the previous year's estimate.

Acknowledgments

We would like to thank I. Leach, Dr M. Marquiss, G. Sheppard, R.T. Smith and J.F. Young for providing records of breeding Barn Owls. We are grateful to all the landowners and their agents for access to their land and buildings during the study, and to the NCC, SOC and WWF for financial assistance.

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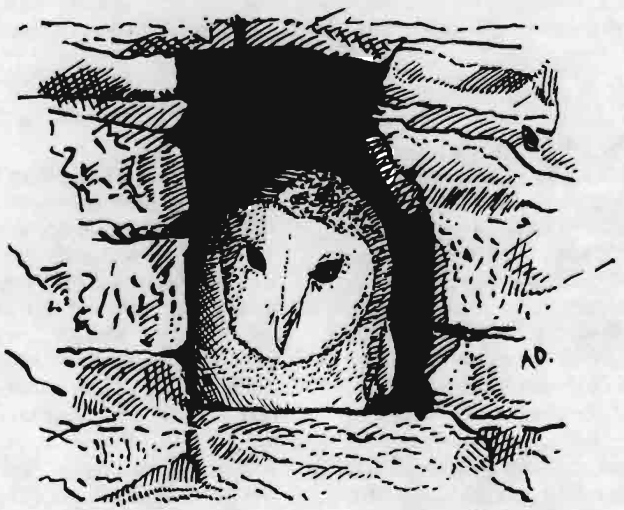

Barn Owl **Andrew Dowell**

Short Notes

Sexing and distinguishing juvenile Dotterel in summer

Juvenile Dotterel *Charadrius morinellus* fall into two categories of size and colour. These are clear among individuals in each brood, as early as when they still retain traces of down on the head and nape. Young in the smaller size category are brownish-grey, with off-white eye-stripes and breast stripes. A good field character is that young in the bigger category are warmer brown, their dark and light parts both being suffused with a creamy, fawn, or cinnamon colouring. They also have a pale, fawn-coloured eye-stripe which is broader relative to body size. The pale colouring in their eye-stripe narrows immediately in front of the eye and then broadens into a big patch of similar-coloured pale feathers on the cheek and chin; both cheek and chin usually have fewer greyish feathers than in the smaller-category young. I suggest that the smaller-category young are cocks and the larger ones hens; this could be tested by ringing chicks and noting their sex as adults in later years. The size difference is not surprising, as adult hen Dotterel greatly surpass cocks in size. Other species where adult cocks and hens differ greatly in size show big sexual differences in the body size of feathered young in each brood; these are easily proven in some cases such as Capercaillie *Tetrao urogallus* by the fact that young cocks grow blackish feathers long before the brood is fully fledged.

BWP Vol III states "juvenile separable at close range", but in summer it is easy to tell juvenile from adult at over 100 m. Watson (*SB* 4: 179-203) wrote "fully grown young are remarkably unlike the adults in plumage, having a generally creamy ground colour with heavy blackish marks on the wings and back". The predominant colour on their wings and back is much darker, and most of the feathers there are edged narrowly with a paler colouring than in adults, giving a far more contrasty, dappled pattern. The difference is so great that juveniles at first sight might seem a different species.

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Pintail breeding on Colonsay

On 14 May 1986 while visiting Colonsay, Roy and Joan Ramage of Alloa found a pair of Pintail *Anas acuta* with seven small young, one of which appeared very weak. On 17 May they saw the female with six young. Two pairs of Shelduck *Tadorna tadorna,* two pairs of Eider *Somateria mollissima* and a pair of Mallard *Anas platyrhynchos* also had broods in the same area although of these, only one pair of Shelduck raised young to fledging. There is regular disturbance by humans in the area and adult birds frequently leave their young exposed to predators such as gulls, *Larus* spp., Crows *Corvus corone* and Herons *Ardea cinerea* all of which are plentiful. The Pintails may have had some advantage over the other ducks by their more nocturnal habits (*BWP* Vol I). Although the female was seen on several occasions, the young were more difficult to find. Sightings of the female with six young on 30 May (J. Clarke) and four large young on 4 July (G. Riddle) were reported. The male was seen on only one other occasion, on 14 July (D. Gibby). This is the first confirmed breeding record for Pintail on Colonsay. There have been only five previous recorded sightings for the island. At most *c.*20 pairs breed in Scotland; breeding is sporadic except in Orkney and Caithness (Thom V.M. 1986. *Birds in Scotland.* Poyser, Calton).

J. & P.M. Clarke, Isle of Colonsay, Argyll

Black-headed Gulls as predators of breeding Sand Martins

Mead & Pepler (*BB* 68: 89-99) documented predation of Sand Martins *Riparia riparia* at breeding colonies during the BTO ringing enquiry into this species. Black-headed Gulls *Larus ridibundus* were recorded approaching martin nestholes at several colonies, although the gulls were thought to be feeding on fleas. Black-headed Gulls were also noted taking the contents of exposed nests after cliff collapses, but there was no evidence of gulls as active predators rather than scavengers at Sand Martin colonies.

During 1982 a colony of about 37 pairs of Black-headed Gulls nested beside a colony of *c.*920 pairs of Sand Martins at Barbush sand quarry, near Dunblane in Central Scotland. The gulls were the most frequently observed predators of martins at the colony that year, and at least five chicks were taken. Adult gulls typically approached burrow entrances where full-grown Sand Martin nestlings awaited feeding, and if successful, pulled the nestlings from the burrow and carried them away. The martin nestlings normally retreated from their burrow entrance if a gull appeared, and gulls were mobbed by adult martins. Most of the gulls' attempts at taking nestlings were unsuccessful. Only one nestling was taken at each successful predation attempt. One nestling aged about 20 days was forced to be dropped by a flying gull, but was dead on retrieval.

Carrion Crows *Corvus corone* employed similar tactics to the gulls at Sand Martin burrows, although only the gulls, and on one occasion a Kestrel *Falco tinnunculus* were noted as successful predators.

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Two cases of a yearling and an adult male Merlin attending the same nest site

On 31 May 1986 we found a Merlin *Falco columbarius* nest with four eggs on the ground on a grouse moor in lower Deeside, Grampian. A yearling male (i.e. in brown plumage) called the female off the nest and was seen passing food to her. He then went to the nest. About five minutes later, after eating the prey, the female returned to the nest and the male left. When we examined the nest 30 minutes later the female and the yearling male both called in alarm. On 21 June a pair alarm-called but the male was notaged. On 7 July only the female was present, sporadically, during our four-hour visit to the area. On 16 July four young had fledged and a full adult male (i.e. in blue-grey plumage) delivered food to one of them. This male and the female were present for the next hour.

Similar behaviour was observed in 1987 at a young conifer plantation 30 km away. A pair of Merlins display-called over the territory (T1) on 26 April. During 1 and 2 May the male at T1 was seen to be a yearling. On 26 April at a neighbouring territory 1 km away (T2) a pair was established and the male was in full adult plumage. He prospected an old Crow *Corvus corone* nest on 1 May and 'scraped' it on 2 May. A female was present both times. On 8 and 16 May no Merlins were seen or heard at T2 but in T1 on 16 May a yearling male was incubating five eggs in an old Crow nest in a Scots pine *Pinus sylvestris*. When disturbed the male was soon joined by a female and both called. On 7 June T2 was unoccupied and T1 still active with the yearling male and the female defending it. On 16 June all the eggs had hatched and the young were about one week old. The female was very aggressive during this five minute visit; no male was present. On 29 June a male in full adult plumage flew from the nest tree calling. The female arrived with prey three minutes later and both then alarm-called. They were present for the next 40 minutes, while the five young were weighed, measured and ringed. On 8 July during a three-hour watch the adult male (twice) and the female delivered food to the five recently

fledged young. The first delivery from the male involved him calling to and being answered by the young for fully three minutes. On 12 July four young were seen flying strongly and the adult male brought food to one of them. For all the males (except on 21 June 1986) we had excellent close range views using good quality optics.

Yearling male Merlins begin a partial moult during February to May and subsequently complete their moult into adult plumage between September and November (*Moult in Birds.* BTO Guide 19). At other nests in Grampian where the male was a yearling, each was still in brown plumage at the end of the breeding season in late July. In the closely related and similarly sized Kestrel *F. tinnunculus* yearlings do not complete their moult into adult plumage until October/November of their second year, and raptors in general have a long moult period (BTO Guide 19). It is therefore extremely unlikely that the yearling males at the nests we have described could have moulted into full adult plumage between our observations. Male Merlins have twice been reported as being replaced by another male during the same breeding season (Newton, I. 1979. *Population Ecology of Raptors.* Poyser, Berkhamsted). This happened after the original males had been shot. We have no evidence for persecution at the Grampian nests, and it is very unlikely. In 1986 the occupation of the eight surrounding territories seemed to rule out any surplus adult males locally; four held pairs (three with adult males and one with a yearling), two held single females and two were unoccupied. The food delivery on 16 July 1986 could have been instinctive, perhaps by a neighbouring male or a failed breeder from further afield. After prospecting the Crow nest on 1 May 1987 the adult male flew to T1 and displayed there. We believe he eventually moved from T2 to T1 either after failing to breed or an early breeding failure. There were probably no other surplus adult males nearby as three of the five surrounding territories were unoccupied.

Unfortunately our observations were too few to decide whether the yearling males died, left voluntarily, were displaced, or briefly, were acting as 'helpers' (although in each case the younger male initiated the nest). It would be interesting if other Merlin enthusiasts could monitor extensively nests with a yearling male in attendance.

We should like to thank Eric Meek and the editorial panel for their comments on this note.

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Sparrowhawk specialising on Swifts

Every year a pair of Sparrowhawks *Accipter nisus* nests on an island on the River Don in Seaton Park, Aberdeen. This site was one of eight I visited in 1987 to collect prey remains for analysis.

On 1 August 1987 these included Grey Wagtail *Moticilla cinerea,* Chaffinch *Fringilla coelebs,* Wren *Troglodytes troglodytes* and Blackbird *Turdus merula,* but it was surprising also to find the remains of 12 Swifts *Apus apus.* Two were in the nest and consisted of wing bones with outer primaries attached. The 10 found on the ground each consisted of wing feathers and a few breast feathers.

I. Newton (1986, *The Sparrowhawk,* Poyser, Calton) found only one Swift in his analysis of 10,000 kills. It seems clear that the Aberdeen bird specialised in catching Swifts. The nest site overlooked rapids where Swifts were often seen flying low over the water. Individual Swifts were also found at two other Sparrowhawk sites in Aberdeen.

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Items of Scottish Interest

Articles and Reports on birds in Scotland, mainly on status and distribution. (Previous lists 14(3) 189-190; 14(4) 217-218). References from the widely available journals *British Birds, Bird Study* and *Ringing and Migration* are excluded. Most of these items are available for reference in the Waterston Library. Items marked with an asterisk are also available from the SOC Bird Bookshop postfree to SOC members at the prices quoted.

The librarian is glad to receive reprints or copies of papers on any aspect of ornithology or general natural history.

Scientific papers.

Changes in numbers of cliff-nesting seabirds in Orkney, 1976-1985. S. Benn, M.L. Tasker & A. Webb 1987. *Seabird* 10: 51-57.

A Survey of moorland birds on the Campsie Fells/Touch Hills massif, Stirling in 1987. J. Calladine, S. Dougill, K.B. Shepherd, D.A. Stroud, J. Turner & C.M. Crawford 1987. Nature Conservancy Council, Northminster House, Peterborough (Contract Report) 58 pp.

The Outer Hebrides. P. Cunningham 1987. *Sea Swallow* 36: 20-24.

Opportunistic feeding of Black Guillemots at fishing vessels. P.J. Ewins 1987. *Seabird* 10: 58-59.

Sandeels in the diet of the Fulmar in Shetland, Scotland. J.A. Fowler & A.P. Dye 1987. *Seabird* 10: 71-74.

The marine distribution of Sooty Shearwater, Manx Shearwater, Storm Petrel and Leach's Petrel in the North Sea. A.J. Hall, M.L. Tasker & A. Webb 1987. *Seabird* 10: 60-70.

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Birds of Cape Wrath. D. Law 1987. *Adjutant* 17: 10-14.

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Breeding performance of Merlins in North-East Scotland in 1986. G.W. Rebecca 1987. *Hawk Trust Annual Report 1985-86* 15: 12-13.

Colonization of island woodlands in the Hebrides of Scotland. T.M. Reed 1987. *Acta Oecol.* 8: 275-280.

Effects of aerial applications of Fenitrothion on bird populations of a Scottish pine plantation. C.J. Spray, H.Q.P. Crick & A.D.M. Hart 1987. *J. Appl. Ecol.* 24: 29-47.

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Census of breeding Wigeon in Ettrick Forest. D.L. Thomson 1987. Nature Conservancy Council, 12 Hope Terrace, Edinburgh 54 pp.

Numbers, territory size and turnover of Short-eared Owls in relation to vole abundance. A. Village 1987. *Orn. Scand.* 18: 198-204. A study at Eskdalemuir, southern Scotland.

Weight and sexual cycle of Scottish Rock Ptarmigan. A. Watson 1987. *Orn. Scand.* 18: 231-232.

The use of models to influence the grazing sites chosen by Barnacle Geese on Islay, Scotland. X. Zhu, D.C. Houston & S. Percival 1987. *Wildfowl* 38: 46-48.

The Royal Air Force Ornithological Society Expedition to Berneray and Mingulay, June-July 1985. N.A. Smith, B.R. Withers & K.W. Earnshaw 1987. *Royal Air Force Ornithological Society Journal* 17: 1-83.

Bird Reports

Argyll Bird Report for 1986. (78 pp) Argyll Bird Club, C.A. Galbraith & A.R. Jennings (Eds) 1987. *£3.50. This is the 4th report of the Argyll Bird Club. It includes a 37-page species list, a ringing report and several short articles on Corncrakes, Mink, Golden Eagles and on various aspects of forestry and birds.

Borders Bird Report for 1986. (56 pp) R.D. Murray (Ed) 1987. *£2.50.

Fife and Kinross Bird Report for 1986. (34 pp) Fife Bird Club. 1987. *£2.50. Includes a species list, and short reports on seawatching at Fife Ness, etc.

Flannan Islands visits. A.D.K. Ramsay. Unpublished report 3pp.

Lanarkshire Bird Report for 1986. (21 pp) I. English (Ed). An unpublished report for the RSPB Hamilton Area Members Group.

Lothian Bird Report for 1986. (84pp) M.R. Leven & I.J. Andrews (Eds) 1987. *£3.50. The 50-page systematic list includes many useful tables of peak counts of birds, an 8-page report on a census of breeding Little Grebe, Great Crested Grebe and Tufted Duck in the Lothians, and short reports on breeding Fulmars on the East Lothian mainland, on breeding Mute Swans, Goose counts and Water Rails.

North-East Scotland Bird Report for 1986. (52 pp) M.L. Tasker (Ed) 1987. *£2. Includes a detailed species list, and a 9-page report on seabirds breeding on the coast of North-East Scotland.

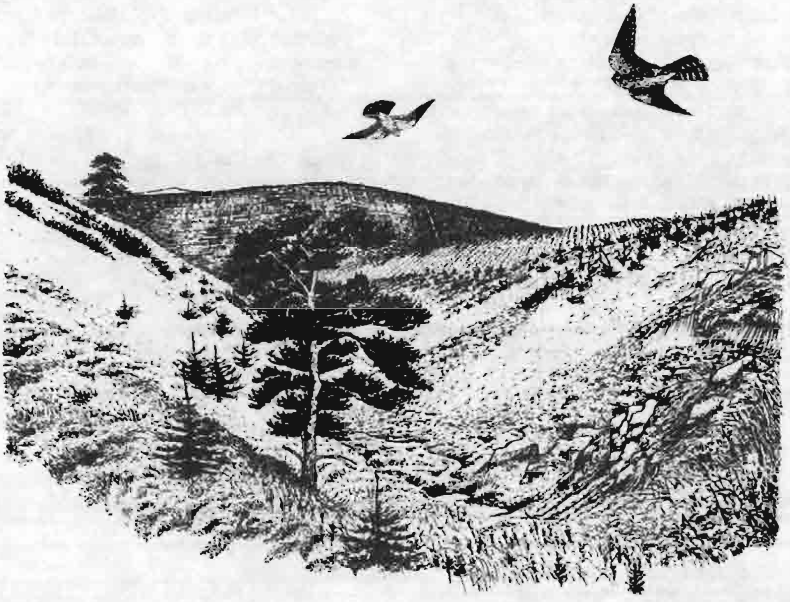
Stewartry and Wigtown Districts Bird Report for 1986. (17 pp) A.D. Watson (Ed) 1987. *£1.95. The 2nd annual report for this part of Dumfries and Galloway Region.

Tay Ringing Group Report for 1984-86. (64 pp) Tay Ringing Group, Dundee 1987. 43 pages of this report are studies of Dunnocks, Sedge Warblers, Sandmartins, Siskins and Mute Swans.

Dungavel Area Bird Report for 1983-1986. (43 pp) R. Morton & I. Livingstone (1987). A detailed study of an area of moorland on the borders of Lanarkshire and Ayrshire which has been increasingly afforested over the period. Unpublished report.

Holyrood Bird Records 1986. (5 pp) L.L.J. Vick 1987. A brief account of birds seen in Holyrood Park, Edinburgh, which includes Duddingston Loch and the Bawsinch Reserve. Unpublished report.

W.G. Harper



Merlins **B.L. Cosnette**

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Authors should bear in mind that only a small proportion of the *Scottish Birds* readership is science-trained, and should aim to present their material concisely, interestingly and clearly. Unfamiliar technical terms and symbols should be avoided wherever possible and if deemed essential should be explained. Supporting statistics should be kept to a minimum. All papers and short notes are accepted on the understanding that they have not been offered for publication elsewhere and that they will be subject to editing. Papers will be acknowledged on receipt and will be reviewed by at least two members of the editorial panel, and in some cases also by an independent referee, before being accepted. They will normally be published in order of acceptance of fully revised manuscripts. The editors will be happy to advise authors on the preparation of papers.

Reference should be made to recent issues of *Scottish Birds* for guidance on style of presentation, use of capitals, form of references, etc. Papers should be typed on one side of the paper only, double-spaced and with wide margins; two copies are required and the author should also retain one. Headings should NOT be underlined, nor typed entirely in capitals. Scientific names should follow the first text reference to each species and should follow Voous' 'List of Recent Holarctic Bird Species' as given in *The British Birds' List of Birds of the Western Palearctic* (1984).

Tables, maps and diagrams should be designed to fit either a single column or the full page width. Tables should be self-explanatory and headings should be kept as simple as possible, with footnotes used to provide extra details where necessary. Each table should be on a separate sheet. Maps and diagrams should be in Indian ink and drawn so as to permit reduction to half their original size. If necessary they may be submitted without lettering and accompanied by a photocopy showing the lettering required. Captions should be typed on a separate sheet. Relevant line-drawings (in ink) will be welcomed, as will photographs (preferably black & white glossy prints).

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