INTEGRATED SEABIRD MONITORING STUDIES ON THE ISLE OF CANNA, SCOTLAND 1969-99

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An annual survey of breeding seabird numbers on the Isle of Canna, western Scotland, was established in 1969; the breeding productivity of several species is also monitored each year. Over 53 000 seabirds have been ringed since the study started and the subsequent recoveries and recaptures have been used to assess changes in survival rates and return rates to the island. Northern Fulmars Fulmarus glacialis *have shown great fluctuations in numbers since 1973 and from 1996-99 there has been a noticeable decline accompanied by a decrease in breeding output. The percentage of study burrows occupied by Manx Shearwaters* Puffinus puffinus *began to decline in the late 1980s and breeding success has also declined; the species is now close to extinction on the island. Shags* Phalacrocorax aristotelis, *Kittiwakes* Rissa tridactyla *and Common Guillemots* Uria aalge *all showed a steady increase in numbers up to the mid 1980s, after which numbers declined or, in the case of Guillemots, stabilised until the early 1990s when further increases took place. During the periods of population growth return rates of young Shags and Guillemots were high but they subsequently declined during the period of population decline/stability and in the case of Guillemot this was linked to a significant increase in first-year recovery rates. The period of decline was also associated with a drop in Shag and Kittiwake breeding output. These changes were probably driven by fluctuations in the food supply, although increased predation might have affected Fulmar and Manx Shearwater numbers.*

Swann R.L. 2000. Integrated seabird monitoring studies on the Isle of Canna, Scotland 1969-99. Atlantic Seabirds 2(3/4): 151-164.

INTRODUCTION

Canna, one of the Small Isles, is situated south of Skye at the southern end of the Minch off north-west Scotland (Fig. 1). It was recently declared a Special Protection Area under the EC Birds Directive for its nationally important concentrations of breeding seabirds. Seabird monitoring began here in 1969 as part of Operation Seafarer, the first complete census of all seabird colonies in Britain and Ireland. The island has been visited every year since 1969, rendering it one of the longest continuously running seabird monitoring sites in the British Isles (Swann & Ramsay 1984). In 1986 it was adopted as one of the core monitoring sites in the UK Government's Joint Nature Conservation Committee Seabird Monitoring Programme. The aim of this paper is to describe the long-term population trends of five breeding seabird species on the island and to explore the possible causes of the observed trends.

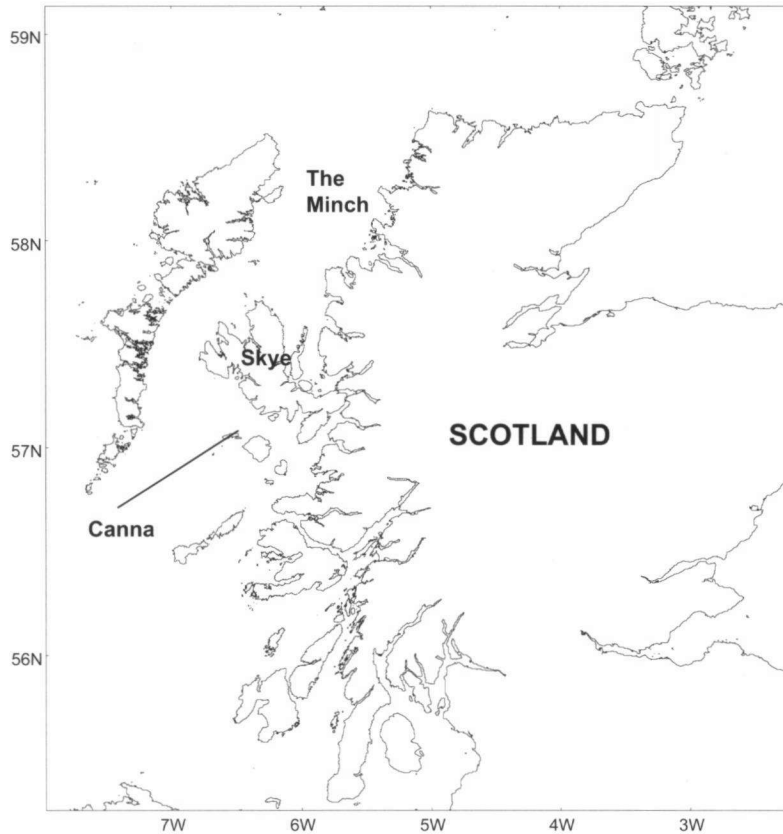


Figure 1. Map of Scotland showing location of Canna.

METHODS

With the exception of Puffins *Fratercula arctica*, all breeding seabirds (including Northern Fulmar *Fulmarus glacialis*, Shag *Phalacrocorax aristotelis*, Kittiwake *Rissa tridactyla*, Common Guillemots *Uria aalge* and Manx Shearwaters *Puffinus puffinus*) are counted each year using standard techniques (see Swann 1997). For some species whole island counts before 1974 are not available. Breeding productivity is also monitored for Manx Shearwater, Fulmar, Shag and Kittiwake; see Swann (1997) for methodology. A major ringing programme is also undertaken annually; as far as possible this involves

the same number of people visiting the same sites each year for the same amount of time to ensure constant effort. To date, around 53 000 seabirds having been ringed on the island since 1969. Recoveries and retraps resulting from this ringing programme have been used to compute survival rates and rates of return to the colony, particularly for auks (Swann & Ramsay 1983; Swann *et al.* 1989; Harris *et al.* 2000) and Shags (Swann *et al.* 1994). These analyses are reviewed and updated in this paper.

RESULTS

Population changes The mean number of Fulmars breeding annually since 1973 is 541 apparently occupied sites (AOS). Numbers appear to have remained fairly stable but have fluctuated considerably in that time (Fig. 2). Since 1995 there has been a particularly pronounced decline in numbers.

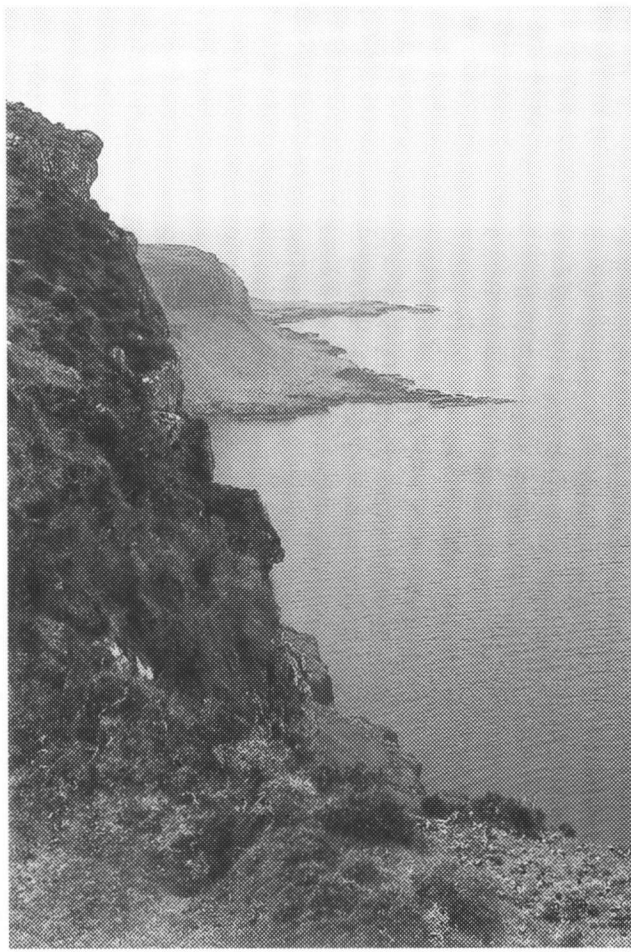
The Canna Manx Shearwater colony was first counted in 1973 and 1974 (Swann and Ramsay 1976) and from the 1974 total of 1303 occupied burrows it was estimated that the island population was in the order of 1000-1500 pairs. The occupancy of 60 randomly positioned observation burrows remained fairly constant until 1984 (Swann 1995). It was assumed that for the second complete census of all seabird colonies in Britain and Ireland, the Seabird Colony Register (1985-87) that no major change in numbers had occurred and the population was estimated at >1000 pairs in 1985. It was only in the 1990s that the sudden decline in burrow occupancy rates (Fig. 6) indicated that the breeding population had greatly declined. In late May 1997, using a tape playback method, all known colonies on the island were surveyed (Swann 1997); only 33 calling birds responded from 952 burrows. Using the correction factor of 1.98 given by Brooke (1978) this suggested a total of only 65 occupied burrows. A similar survey repeated in 1999 failed to elicit a response from any burrow.

From the mid-1970s the number of Shags nesting on Canna rose steadily to reach a peak of 1753 nests in 1984, after which numbers decreased to a low of 697 nests in 1993 and then increased to 1140 in 1998, followed by another reduction in 1999 (Fig. 3). Extremely poor weather caused large decreases in 1976 and 1986.

Kittiwake numbers on Canna increased to reach a peak of 991 nests in 1982 (Fig. 4). Numbers then slowly and erratically decreased to 693 nests in 1994, since when there has been a rapid increase to a new peak of 1252 nests in 1999.

Guillemot numbers in Canna study plots at the main colonies on the north of the island increased rapidly up to 823 'nests' in 1983. There then followed a period of relative stability to 1993, after which there is some

evidence of a modest increase, the scale of which has not been fully documented (Fig. 5). The years 1997-99 were characterised by mild winters leading to earlier than average egg laying, which also coincided with slightly later than usual field visits to the study colonies. Consequently, many birds had left the colonies, resulting in underestimated counts. Observations showed that breeding birds had occupied many new sites, suggesting an increase in total numbers in the colony.



North Coast of Canna (photo C.J. Camphuysen).

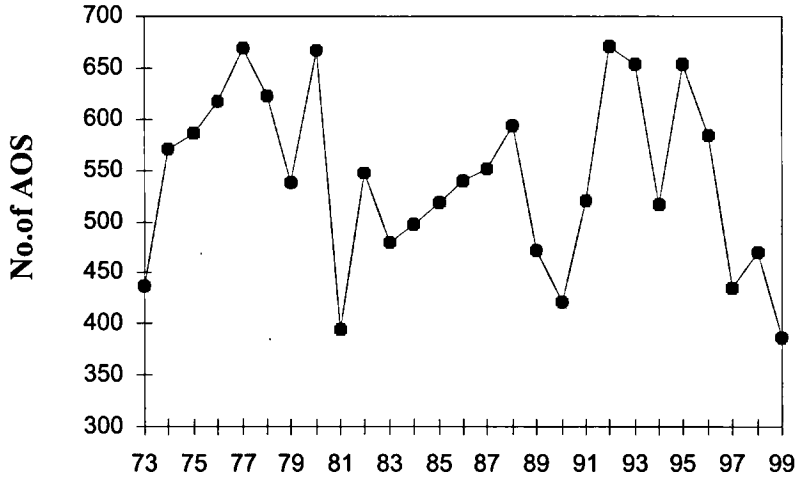


Figure 2. Number of apparently occupied Northern Fulmar sites on Canna 1973-99.

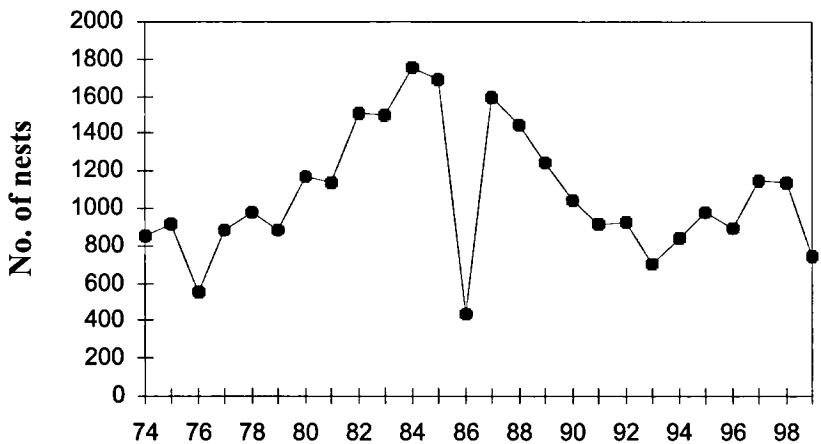


Figure 3. Number of Shag nests on Canna 1974-99

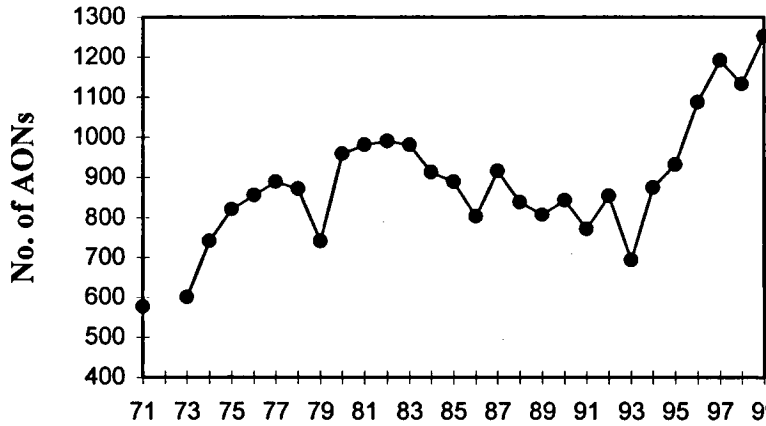


Figure 4. Number of apparently occupied Kittiwake nests (AONs) on Canna 1971-99.

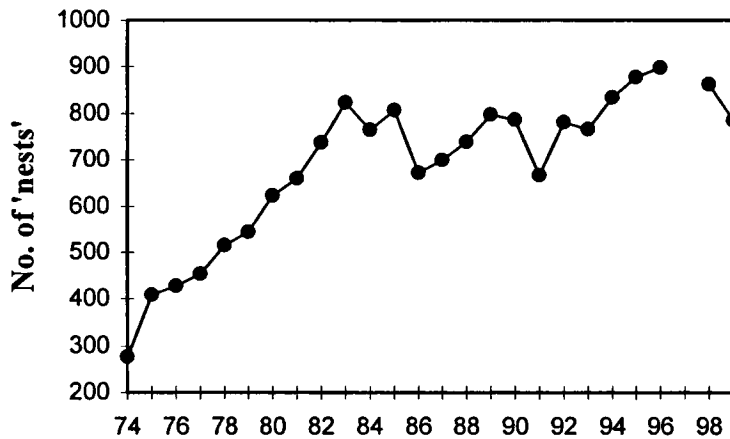


Figure 5. Number of Common Guillemot 'nests' in sample plots on the North cliffs of Canna 1974-99.

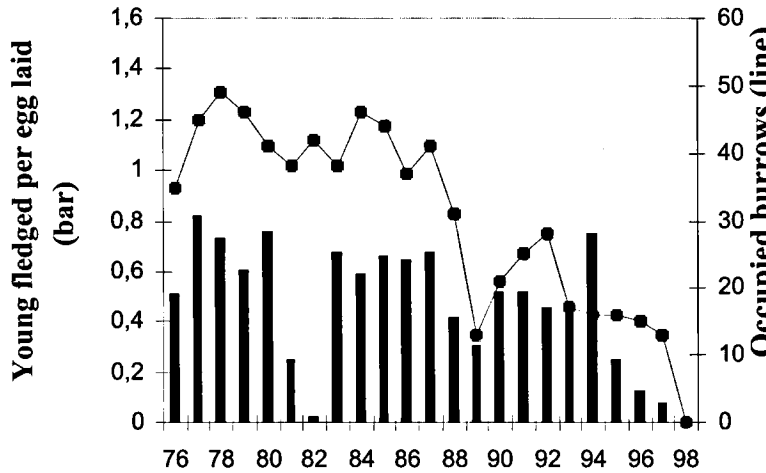


Figure 6. Number of study burrows occupied by Manx Shearwaters on Canna and breeding success as measured by number of eggs in occupied study burrows that produced a large chick.

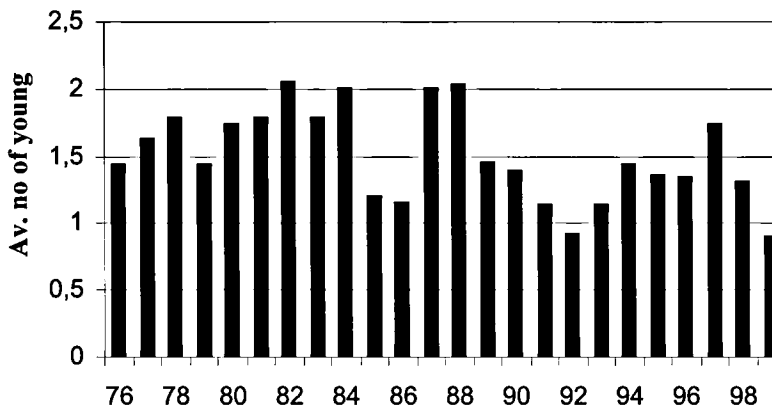


Figure 7. Average number of young Shags fledged per study nest on Canna 1977-99.

Breeding productivity Between 1986 and 1995 the combined number of monitored Fulmar AOS at two study plots varied annually from 42-50 while productivity varied from 0.31 to 0.54 chicks fledged per site per year. There was no significant difference between the two study plots. Since 1995 the number of AOS has declined (to 35 in 1998) and breeding productivity has also declined sharply with only 0.22-0.27 chicks fledged per site. This decline from a 1986-95 mean of 0.37 chicks per AOS to the 1996-98 mean of 0.24 is significant $\chi^2_1 = 5.038$, $P < 0.05$).

Breeding productivity of Manx Shearwaters up to 1987 was usually around or greater than 0.6 young per pair laying an egg (Fig. 6). Exceptions in 1976, 1981 and 1982 were linked to rat predation, which was counteracted by scattering the rat poison Warfarin throughout the colony in each of the following springs (Swann 1995). After success in 1987, however, the number of occupied study burrows and breeding success began to decline.

Shags are currently monitored at two colonies on the island. Productivity was relatively high between 1977 and 1984 (Fig. 7). It then fluctuated reaching a low in 1992, since when it has improved during a period of rapid colony growth but has not yet returned to the levels of the 1980s.

Kittiwake productivity has been highly variable since monitoring began in 1986 (Table 1), varying from almost total failure in 1988 to 1.21 chicks fledged per AON in 1990. Breeding success was particularly poor between 1986 and 1989, during a period of decline in breeding numbers on the island (Fig. 4).

Table 1. Kittiwake productivity in Sanday study colony 1986-99.

Brood size	86	87	88	89	90	91	92	93	94	95	96	97	98	99
0	99	170	224	109	44	61	86	92	78	89	77	90	113	106
1	70	64	7	52	52	53	79	63	70	69	98	92	101	111
2	18	46	0	22	76	57	30	26	51	61	62	81	44	21
3	0	0	0	0	2	0	1	0	0	3	0	3	2	0
Av*	0.57	0.56	0.03	0.52	1.21	0.98	0.72	0.63	0.86	0.90	0.94	0.99	0.75	0.64

* average number of chicks fledged per AON (apparently occupied nest)

Ringing recovery rates, survival rates and rates of return to the colony Ringing studies have been used to monitor recovery rates, survival rates and rates of return to the colony of Shags and Guillemots. The recovery rate of Shags ringed on Canna has declined throughout the entire study period (Table 2). This fall in recovery rate was associated with significant changes in recovery circumstances, with far fewer birds being shot and netted than was previously the case (Table 3). This has been associated with significant changes in the location and timing of recoveries, with far fewer ringed Shags now being

reported from the Western Isles and far fewer in winter (Swann *et al.* 1994). These changes are all associated, as large numbers of Shags were formerly shot in the Western Isles in winter for food. There have also been changes in return rates to the colony (Table 4). These were highest during the period 1974-81, then declined and have risen again since 1987. There is no significant correlation between retrap rates (by age 7) and first year recovery rates of different annual cohorts of Shags ringed as chicks on Canna ($r_s = 0.081$, $n = 19$, $P > 0.05$).

Table 2. Recovery rate of Shag chicks ringed on Canna 1961-98.

	no.ringed	no. (%) recovered in first year	no. (%) recovered in 2nd and 3rd year
1961-70	617	45 (7.3%)	12 (1.9%)
1971-81	4005	125 (3.1%)	26 (0.6%)
1982-91	4758	83 (1.7%)	26 (0.6%)
1992-98	3660	43 (1.2%)	4 (0.2%)*

* based on 2310 chicks ringed 1992-96.

Note: Most Shags enter the breeding population in third year of life. Chicks ringed 1971-81 entered the colony during a period of rapid growth, those ringed 1982-91 during a period of decline, and those from 1992 onward during another period of growth. For those ringed 1961-70 there are no details of colony size.

Table 3. Recovery circumstances of Canna Shags in their first year of life.

Reported as:	1961-70	1971-81	1982-91	1992-98
found dead	25	78	67	42
shot	13	30	1	0
netted	7	16	12	1
oiled	0	1	4	0

Table 4. Return rates of Shag chicks to Canna by ages 3-7.

year	no. ringed	no. retrapped	% retrapped in colony
1974-81	3556	132	3.7%
1982-86	2045	33	1.6%
1987-91	2713	58	2.1%

Note: Those ringed in 1974-81 would, by age 7, have been returning during a period of colony growth, those ringed 1982-86 during a period of decline and those ringed 1987 onwards during another period of colony growth.

The recovery rate of Guillemot chicks ringed on Canna in their first year of life has shown major changes over time (Table 5). The recovery rate until 1979 was 1.1%, then significantly increased by more than double between 1980-85 ($\chi^2_1 = 26.14$, $P < 0.001$), since when it has significantly declined, with the 0.8% recovery rate of chicks ringed 1991-98 not significantly different from the 1974-79 cohorts ($\chi^2_1 = 0.017$, $P > 0.05$). The recovery rates of birds in their second and third years were significantly lower in the period 1986-96 compared with 1974-85 ($\chi^2_2 = 26.493$, $P < 0.001$).

These long term changes in the mortality rates of young birds will influence recruitment rates and therefore breeding numbers on Canna. Most Guillemots do not start breeding till at least 5 years old (Harris *et al.* 1994). Return rates were calculated using the percentages of each cohort of ringed chicks retrapped in the colony by age 5. These return rates are highly variable and show significant changes with time (Table 6). The return rate of the 1979-89 cohorts was significantly lower than the 1974-78 cohorts ($\chi^2_1 = 26.952$, $P < 0.001$) and the 1990-94 cohorts ($\chi^2_1 = 15.681$, $P < 0.001$). Return rates also show a negative correlation with recovery rate ($r_s = -0.59$, $n = 20$, $P < 0.01$; Fig. 8). Changes in survival rates of breeding adults will also affect breeding numbers on the island. Mortality rates of breeding adults on Canna based on mark-recapture analysis indicate an average survival rate of known breeders caught between 1983 and 1995 of 92.4% (SE = 0.9; Harris *et al.* 2000). No significant variation in survival rates between years was detected over the study period.

Table 5. Recovery rates of Canna Common Guillemot chicks in their first to third year of life.

	no. ringed	recovered 1st year	Recovered 2nd year	recovered 3rd year
1974-79	2936	32 1.1%	16 0.5%	14 0.5%
1980-85	9518	266 2.8%	52 0.5%	30 0.3%
1986-90	10103	181 1.8%	34 0.3%	15 0.1%
1991-98	16138	128 0.8%	44 0.3%*	16 0.1%**

* based on 15 291 ringed in 1991-97, ** based on 12 659 ringed in 1991-96

Table 6. Return rates of Common Guillemot chicks to Canna by age 5 according to time period ringed.

Time period	no. chicks ringed	no. chicks returned by age 5 to colony	% returned
1974-78	2688	68	2.5
1979-89	17433	213	1.2
1990-94	11631	210	1.8

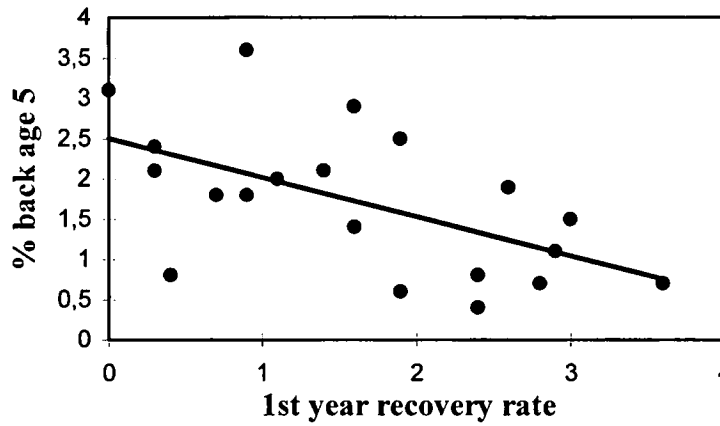


Figure 8. Percentage of young Common Guillemots returning to Canna by age 5 compared to the first-year recovery rate of that cohort.

DISCUSSION

Until 1996, Fulmar numbers and breeding success fluctuated from year to year showing no significant trends. Since 1996, however, there has been a marked decline in both numbers and breeding success. This decline in numbers may be linked to increased predation from large raptors, which bred successfully on the island in 1997 and 1998. As a result of this predation, many Fulmars now nest well back under boulders, which renders them more difficult to count. Increased rates of predation by both avian and mammalian predators are also suspected for the reduction in breeding success.

There is circumstantial evidence, based on partly eaten adults and chicks (Swann 1997), that the decline in breeding success and the total number of Manx Shearwaters breeding on Canna is related to an increase in numbers of mammalian predators, probably cats and rats, possibly due to milder winters. Both species have been seen more frequently on the island in the 1990s than previously. Despite an attempt by the National Trust for Scotland from 1998 to control these predators, the evidence from the 1999 census suggests it is too little, too late and that the Manx Shearwater colony on the island faces extinction.

Shag numbers have shown great changes on Canna since monitoring began. Between 1974 and 1984, there was a period of rapid colony growth, ostensibly driven by above average breeding success and also, despite apparently high recovery rates of first-year birds, very high return rates to the colonies. Until 1981, reporting rates of dead first-year birds were greatly inflated by the numbers being shot and reported in the southern islands of the Western Isles. Following protection by the 1981 Wildlife and Countryside Act, the reporting rate declined markedly, although the possibility remains that birds continued to be shot and not reported. From 1984-93, breeding numbers decreased to early 1970s levels. This was characterised by a decline in breeding success and a fall in return rates of young Shags to Canna to breed, indicating that conditions were much less favourable for Shags during that period. Since 1993, breeding success and return rates to the colony have once again improved and this has led to the colony increasing in numbers. Shags on Canna feed on a variety of fish but mainly sandeels and gadoids and there is some evidence that the more sandeels in the diet then the higher the breeding success (Swann *et al.* 1991). It is likely that the amount of fish available to Shags in the Sea of the Hebrides affects breeding success and first year survival rates, which in turn affects recruitment rates and therefore colony growth.

The Kittiwake population on Canna also exhibited a period of growth up to the early 1980s followed by a decline. During the period of decline breeding success was very low. Since 1993, the colony has grown rapidly and there has been a sustained improvement in breeding success. This is perhaps linked with an increase in the availability of sandeels around Canna in recent summers (Swann 1997).

Guillemot numbers steadily increased to peak in 1983 and then stabilised somewhat. The period of population growth was associated with low first-year recovery rates. There is a strong negative correlation between first-year recovery rate and return rates to their Canna breeding colonies of birds up to age 5. During the period of relative stability there was a marked increase in first-year recovery rates and a decline in return rates. As recovery rates have fallen since 1986 return rates have improved and there has been some evidence of colony growth again since 1993 (see Results). It appears that survival rates of birds in their first year of life regulates colony growth, as recovery rates of birds in their second and third years of life are not correlated with changes in colony size and no significant changes have been found in the survival rates of breeding adults.

By continued low level population monitoring it has been possible to track the fortunes of seabirds on Canna and to explain some of these changes by also monitoring breeding performance and diets; the ringing and retrapping programme enables survival rates to be monitored. Several species show a

similar pattern of success with a rise in numbers to the early 1980s, followed by a decline to the early 1990s and followed by another rise. Periods of population decline were generally associated with poorer breeding productivity and lower return rates of chicks to the colony and these are probably linked to the availability of fish. In more recent years increased predation levels are beginning to affect the numbers and breeding success of some species on the island.

ACKNOWLEDGEMENTS

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SAMENVATTING

BROEDVOGELMONITORING VAN ZEEVOGELS OP HET EILAND CANNA, SCHOTLAND, 1969-99

In 1969 werd op het eiland Canna (Small Isles, West Schotland) een jaarlijkse telling van de broedende zeevogels ingesteld. Daarnaast werd het broedsucces van verschillende soorten elk jaar gemeten. Sinds het begin van het onderzoek op Canna werden ruim 53 000 zeevogels geringd en de talrijke terugmeldingen en terugvangsten zijn gebruikt om de jaarlijkse overleving en terugkeer van zeevogels op Canna in te schatten. De populatie Noordse Stormvogels Fulmarus glacialis *schommelde sinds 1973. Sinds 1996 is sprake van een sterke achteruitgang gepaard gaand met een vermindering van de broedresultaten. In de jaren zeventig werd de populatie van de Noordse Pijlstormvogel* Puffinus puffinus *op 1000-1500 paar geschat. Eind jaren tachtig begon het aantal bezette nestholen af te nemen, evenals het broedsucces. De soort staat op Canna nu op de rand van uitsterven. Kuifaalscholvers* Phalacrocorax aristotelis, *Drieteenmeeuwen* Rissa tridactyla *en Zeekoeten* Uria aalge *namen alle gestaag toe tot aan het midden van de jaren tachtig, waarna de aantallen weer zijn afgenomen of, zoals in het geval van de Zeekoet, zijn gestabiliseerd. Vanaf begin jaren negentig vertoonden de populaties van de drie sooren weer een toename. Bij zowel de Kuifaalscholver als de Zeekoet keerden veel jongen naar het eiland terug in perioden dat de populatie groeide, maar het aantal rekruten (terugkerende jongen als broedvogels in de eigen populatie) liep sterk terug in perioden dat het bestand stabiliseerde of afnam. Gedurende de periode van populatie-afname was het broedsucces bij zowel Kuifaalscholver als Drieteenmeeuw laag. Aangenomen wordt dat de lokale voedselomstandigheden in die jaren onvoldoende waren. Bij Noordse Pijlstormvogel en in mindere mate Noordse Stormvogel heeft een toegenomen predatie in ieder geval een negatieve invloed op de broedresulaten.*

REFERENCES

Brooke M. de L. 1978. Sexual differences in voice and individual vocal recognition in the Manx Shearwater (*Puffinus puffinus*). Animal Behav. 26: 622-629.

Harris M.P., D.J. Halley & R.L. Swann, 1994. Age of first breeding in Common Murres. Auk 111: 207-209.

Harris M.P., Wanless S., Rothery P., Swann R.L. & Jardine D. 2000. Survival of adult Common Guillemots *Uria aalge* at three Scottish colonies. Bird Study 47: 1-7.

Swann R.L. 1995. Numbers and breeding success of Manx Shearwaters on the Isle of Canna, 1973-94. Scott. Birds 18: 56-57.

Swann R.L. 1997. Canna seabird studies 1997. JNCC Report No. 268. Joint Nature Conservation Committee, Peterborough.

Swann R.L. & A.D.K. Ramsay 1976. Scottish shearwaters. Seabird Report 5: 38-41.

Swann R.L. & A.D.K. Ramsay 1983. Movements from and age of return to an expanding Scottish Guillemot colony. Bird Study 30: 207-214.

Swann R.L. & A.D.K. Ramsay 1984. Long term seabird monitoring on the Isle of Canna. Scott. Birds 13: 40-47

Swann R.L., M.P .Harris & D.G. Aiton 1991. The diet of some young seabirds on Canna, 1981-90. Seabird 13: 54-58.

Swann, R.L., D.G. Aiton, J. Carruthers, R. Graham & A.D.K Ramsay 1989. Changes in recovery and retrap patterns of Guillemots ringed on Canna 1974-85. Ringing and Migration 10: 35-40.

Swann R.L., D.G. Aiton, J. Carruthers, R. Graham & A.D.K Ramsay 1994. An analysis of Shag *Phalacrocorax aristotelis* ring recovery and breeding success data during a period of population change on the Isle of Canna. Seabird 16: 50-56.