COUNTS OF ATLANTIC PUFFINS *FRATERCULA ARCTICA* IN THE FIRTH OF FORTH, SOUTH-EAST SCOTLAND IN 2003

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Harris M.P., Wanless S., Murray S., Leitch A. & Wilson. L.J. 2003. Counts of Atlantic Puffins *Fratercula arctica* in the Firth of Forth, south-east Scotland in 2003. Atlantic Seabirds 5(3): 101-110 *The numbers of Atlantic Puffins* Fratercula arctica *breeding at three colonies in the Firth of Forth were estimated in 2003. The Isle of May held 69,300 occupied burrows, making it the largest single colony in Britain and Ireland. This population increased at an average rate of 10.9%* per annum *between 1970 and 2003. Similarly, numbers on Fidra (1466) increased by an average of 9.5%* per annum *over the period 1976-2003. In contrast, the count of occupied burrows on Craigleith (12,100) was less than half of the 1999 estimate. This decline appeared to be due to the rapid spread of an alien plant, the tree mallow* Lavatera arborea. *The geographically distinct population of Atlantic Puffins in east Britain between the Moray Firth and Flamborough Head was estimated at 130,000 occupied burrows in 2003, representing an average rate of increase of 6%* per annum *over the previous 30 years.*

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INTRODUCTION

In Britain, the Atlantic Puffin *Fratercula arctica* has usually been considered a bird of the north and west with the largest colonies on isolated and spectacular islands such as St Kilda, North Rona and Sule Skerry (Cramp *et al.* 1974). However, over the last 40-50 years numbers of Atlantic Puffins nesting on the small, flat islands off the east coast of Scotland and England have increased substantially and several new colonies have established (Smith 1966, 1974; Harris *et al.* 1987). The expansion has been most marked in the Firth of Forth (Fig. 1); this paper reports on counts of burrows made at three colonies in this area (Isle of May, Fidra, Craigleith) in 2003 and assesses the rates of change in numbers in east Britain over the last 30 years.

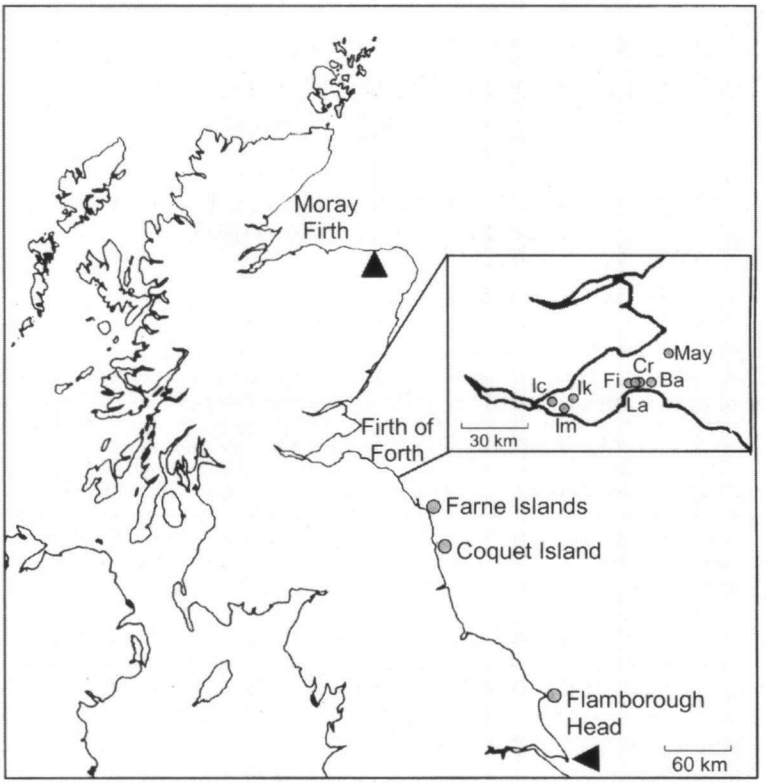

Figure 1. Colonies of Atlantic Puffin in the Firth of Forth, south-east Scotland: Isle of May (May), Craigleith (Cr), Bass Rock (Ba), the Lamb (La), Fidra (Fi), Inchkeith (Ik), Inchmickery (Im) and Inchcolm (Ic). The locations of the large colonies in north-east England and the limits of the local population (triangles) are also shown.

Figuur 1. Papegaaiduikerkolonies in de Firth of Forth, Zuidoost-Schotland: het eiland May (May), Craigleith (Cr), Bass Rock (Ba), the Lamb (La), Fidra (Fi), Inchkeith (Ik), Inchmickery (Im) en Inchcolm (Ic). De ligging van de grote kolonies in Noordoost-Engeland en de grenzen van de lokale populatie (driehoek) zijn eveneens aangegeven.

METHODS

The counting unit employed was the 'apparently occupied burrow', defined as a burrow showing signs of use by Atlantic Puffins such as fresh digging, droppings or regular wear. Where both Atlantic Puffins and rabbits *Oryctolagus cuniculus* occur (as on the Isle of May), there is potential for confusion between the burrows of the two species. However, a rabbit burrow tends to be larger, has more signs of digging, and has characteristic 'pellet' droppings in the entrance. None of the three islands studied has any other species of burrowing bird. For convenience, we use the terms 'burrow' instead of 'occupied puffin burrow'. Additional details of the counts and changes in numbers are given in Wanless *et al.* (2003).

Isle of May Puffins burrow predominantly in the flatter parts of the 55 ha island wherever there is sufficient soil. The count was undertaken by six people between 24 and 27 April 2003 when about half of the burrows contained eggs. The island was divided into 11 areas, each sub-divided into strips 25 m wide with the boundaries marked with bamboo canes. Each observer searched a strip about 5 m wide by zigzagging slowly across and along it. Where there was potential for overlooking burrows or counting them twice, a cane was used to mark the earth in the entrance of each burrow as it was counted.

In order to quantify the detection rate and the classification of burrows a plot *c.* 10x15 m was marked out with string in each of the 11 main counting areas. In five of these plots, the counters marked each burrow with a white plastic tag. In the other six plots, a single counter recorded all burrows he or she found while passing through the plot as part of the main count. Immediately following these counts, MPH, who did not take part in the total count, carried out a detailed examination of each plot, where necessary lying on the ground and feeling to the end of the burrow with a bamboo cane. In each plot, he determined the number of (a) Puffin burrows that had been overlooked (i.e. were unmarked), (b) burrows that belonged to a rabbit rather than a Puffin, (c) entrances that were not true burrows (e.g. were very short), and (d) cases where there were two entrances to a single burrow (i.e. the burrow had been counted twice). Double occupancy of a burrow, where two pairs use a single entrance, is extremely rare so this possibility was discounted.

Censuses of the Isle of May colony have previously been made in late April in 1975, 1984, 1989, 1992 and 1998; similar occupancy checks were made in two of these (Harris & Wanless 1998). In 1992, checks made in four areas suggested that the count had over-estimated the population by 7%, and in 1998, checks suggested an over-estimate of 2%. The probability of overlooking or

wrongly classifying a burrow varies from area to area and from year to year due to the state of the vegetation, soil erosion, burrow density, numbers of rabbits, and other factors. For comparison with previous counts – here and on the other islands – we use the uncorrected burrow counts.

Craigleith About 95% of this 11.3 ha island was covered with a dense stand of tree mallow *Lavatera arborea* reaching a height of 2.5 m. Even in early spring the most sheltered parts of the island were under an almost closed canopy that made counting burrows very difficult and time consuming. As far as was practical the methodology followed that on the Isle of May. The count was made on 19 April 2003 by six counters. Checks of the efficiency of counting and classification in 11 plots were made by SM.

Fidra The count of the 7.4 ha island was made by six people on 4 May 2003 using the methodology outlined above. The efficiency of counting and burrow classification was checked by SM in two plots and these figures are used to give an approximate confidence interval for the count.

RESULTS AND COMPARISONS WITH PREVIOUS COUNTS

Isle of May Burrows were recorded virtually everywhere on the island where there appeared to be sufficient soil. The uncorrected count was 74,517 burrows.

Results from the 11 plots used to estimate observer error indicated that a correction factor of 0.93 should be applied to the raw counts (Table 1). This suggested that the overall count was 7% too high, mainly as a consequence of recorded burrows either being too short for breeding or having several entrances. The 95% confidence limits (CL) for this correction factor, ignoring the one plot where there were just two burrows, were 0.891-0.975. Applying this value to the count total (and rounding off to the nearest 100) resulted in a corrected total of 69,300 (66,400-72,700, 95% CL) occupied burrows.

The early history of the Puffin on the Isle of May is fragmentary (Eggeling 1960; Harris 1977; Harris & Wanless 1998). Before 1960, there were generally fewer than 50 pairs, with most occupying fissures in the cliffs rather than burrows in the central, flatter parts of the island. Numbers increased during the 1960s with about 200 pairs in 1963 and about 2000 pairs in 1970. The first systematic census of the colony was made in 1975 (3064 burrows) and counts were subsequently made in 1984 (12,211), 1989 (18,628), 1992 (20,106) and 1998 (41,542). The average rate of increase between 1970 and 2003 was 10.9% per annum (SE = 0.5%; Fig. 2).

Table 1. Checks of burrow counts and classification of Atlantic Puffin burrows on the Isle of May, Craigleith and Fidra, south-east Scotland in 2003.

Tabel 1. Controle van holentellingen en classificatie van papegaaiduikerholen op het eiland May, Craighleith en Fidra, Zuidoost-Schotland, in 2003.

Plot	Field count	Correctly classified	Mistaken classification		Missed	Corrected count	Correction factor
			Too short or used by rabbit	Second entrance to another burrow			
Isle of May							
1	66	59	4	3	8	67	1.02
2	96	84	9	3	2	86	0.90
3	51	44	3	4	1	45	0.88
4	97	85	5	7	8	93	0.96
5	85	79	1	5	8	87	1.02
6	2					3	1.5
7	80					73	0.91
8	52					51	0.91
9	59					46	0.98
10	40					34	0.85
11	21					19	0.90
Total	649					604	0.93
Craigleith							
1	9	9	0	0	3	12	1.33
2	6	6	0	0	2	8	1.33
3	9	9	0	0	0	9	1.00
4	75	68	7	0	31	99	1.32
5	60	54	5	1	10	64	1.07
6	8	8	0	0	12	20	2.50
7	43	43	0	0	11	54	1.26
8	59	53	3	3	2	55	0.93
9	18	17	1	0	1	18	1.00
10	104	90	12	2	7	97	0.93
11	76	70	5	1	11	81	1.07
Total	467	427	33	7	90	517	1.25
Fidra							
1	57	50	7	0	1	51	0.90
2	54	51	3	0	2	53	0.98
Total	111	101	10	0	3	104	0.94

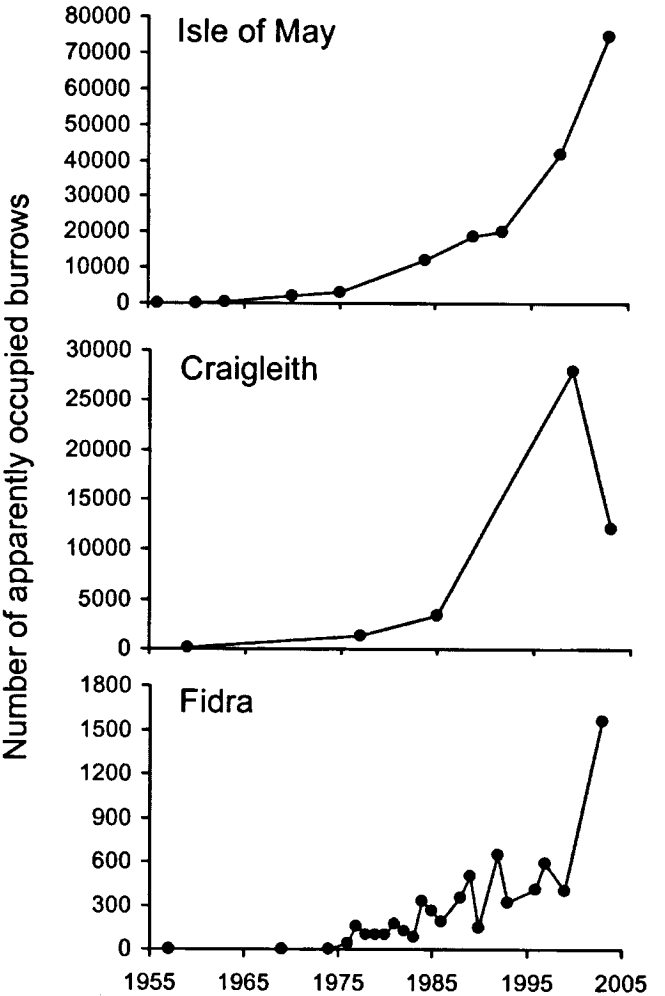

Figure 2. Counts of Atlantic Puffin burrows on the Isle of May, Craigleith and Fidra, south-east Scotland between 1956 and 2003.

Figuur 2. Resultaten van tellingen van papegaaiduikerholen op May, Craigleith en Fidra, Zuidoost-Schotland, tussen 1956 en 2003.

Craigleith The burrow count in 2003 was 9683. Overall, the count appeared to be 25% too low (Table 1), highlighting the problems of counting in tall dense vegetation. The corrected burrow total was 12,100 (9200-15,000, 95% CL).

The only previous estimates of Puffin numbers on Craigleith are 75-100 burrows in 1959, 1325 burrows in 1977, 3361 burrows in 1985, and 28,000 burrows in 1999 (Fairlamb 1998-1999; RWJ Smith *pers. comm.*; Royal Society for the Protection of Birds (RSPB) *pers. comm.*). The 1999 count was based on estimates of burrow density sampled in different habitats and a visual assessment that 55% of the island was covered by tree mallow but no estimate of precision was made. These counts suggest a steady rate of increase of 14.4% per annum (SE = 0.4%) between 1959 and 1999 (Fig. 2). If numbers had continued to increase at this rate, there would have been about 48,000 burrows in 2003 – four times the actual count. We attribute this marked decline to the very obvious recent rapid spread of tree mallow rendering the island much less suitable for breeding Puffins.

Fidra Burrows were dispersed at low density over the island with the exception of the low area to the south-west of the landing, which appeared to be a long defunct rabbit warren with few, if any, Puffin burrows. Tree mallow was present in a localized area near the lighthouse. A total of 1559 occupied burrows was counted. The checks showed that some apparent burrows included in the count were unusable and that the count overestimated the population by 6% (Table 1); the corrected total was 1466 (c. 1388-1528, 95% CL) burrows.

Puffins were first recorded ashore on Fidra in 1966. Four burrows were occupied in 1967 when a single egg was found. Counts have been made in 22 subsequent years (Fig. 2; Andrews 1994-1997; Fairlamb 1998-1999; Jones 2000-2003; RSPB *pers. comm.*). Between 1976 and 2003 the average rate of increase was 9.5% per annum (SE = 1.4%).

DISCUSSION

The 2003 count indicated that the Isle of May was the largest single colony of Atlantic Puffins in Britain and Ireland, with 8% of the Scottish population and 7% of the British and Irish population (Harris & Wanless 2004). Both breeding success and adult survival remain high at this colony (*personal observations*), and in the absence of density dependent effects there is no reason to suppose that the numbers will not continue to increase. At the current rate of increase, the numbers breeding on the Isle of May would double by 2010 and, if the other large colonies in east Britain were to reach carrying capacity (see below), even more birds could be attracted.

The Isle of May had a combined total of 3812 pairs of Herring Gull *Larus argentatus* and Lesser Black-backed Gulls *L. fuscus* in 2003 (Charras & Parkinson 2003). Although there is no evidence that the gulls have a negative impact on Puffin reproductive performance (Finney *et al.* 2001), their presence in areas where Puffins breed at low density reduces the attractiveness to prospecting Puffins (Finney *et al.* 2003). As the density of Puffin burrows increases over most of the Isle of May, gulls may be expected to have less of an effect on recruitment and Puffin numbers might increase at an even faster rate. Given that there are still areas of apparently suitable habitat where the density of burrows is low, there is potential for the colony to increase substantially. Assuming that (a) only 50% of the land surface is suitable for Puffin burrows, (b) none of the already occupied high density areas become unsuitable, and (c) an average density of 1 burrow/m^2, the island could theoretically have a carrying capacity of one quarter of a million burrows.

Within the Firth of Forth the only long established colonies of Puffins are on the Isle of May, Craigleith and the Bass Rock. However, during the last few decades several other islands have been colonised. The numbers of burrows or birds present at these colonies have been counted or estimated in many years (Smith 1966, 1974; Harris *et al.* 1987; Andrews 1994-1997; Fairlamb 1998-1999; Jones 2000-2003; RSPB *pers. comm.*; RWJ Smith *pers. comm.*). Numbers on the Bass Rock have not increased in recent years and there are probably now only about 10 pairs. Puffins were first recorded breeding on Inchkeith in 1965 (three burrows, one egg), although birds were seen ashore in 1961. There was then a rapid increase with 292, 380, 395 and 800-1000 burrows recorded during visits in 1975, 1976, 1978 and 1994, respectively. There are no recent counts of burrows on Inchkeith, but estimates of birds on the sea just off the island suggests that there may currently be more than 2000 pairs at this colony. Colonisation of Inchcolm possibly occurred in 1992 and breeding was proven the following year; in 1995 there were 30 pairs, and in 1997 65 birds. The Lamb was colonised in about 1984 and eight sites (presumably burrows) were recorded in 1985, 56 burrows in 1986 and at least 150 burrows in 1995. Although three Puffins were seen "around" Inchmickery in 1973, there were then few records until three pairs prospected and possibly bred in 1991. In 2003, nine individuals were seen ashore and a further four on the sea. Combining these estimates with our census data suggests that the total population of the Firth of Forth is in the region of 84,000 burrows. This compares with 18,000 burrows in 1985. The cause of this rapid increase is unknown. Many other species of seabirds in the Firth of Forth, with the notable exception of terns *Sterna* spp., have also increased in numbers over the period (Harris *et al.* 1987; Jones 2000-2003). Protection at the colonies may have played a small part but

the food supply, perhaps in both the winter and summer, must surely have increased as well.

The two other major Puffin colonies in eastern Britain (both in Northumberland) were also censused in 2003. The Farne Islands held 55,700 burrows (John Walton *pers. comm.*). Coquet Island held 11,300 occupied burrows and an approximately equal number of apparently unoccupied burrows (Paul Morrison *pers. comm.*); the reason for this high proportion of apparently unoccupied burrows in 2003 was unknown but the total burrow count was very similar to those in 2001 and 2002 (RSPB unpublished data). The various Farne Islands and Coquet Island are small and flat with generally shallow soil - conditions that lead to the collapse of burrows and subsequent soil erosion - and appear to have only limited capacity for further increase in numbers of breeding Puffins.

In 1969-1970, Cramp *et al.* (1974) estimated that there were about 29,000 pairs of Puffins in east Britain between the Moray Firth and Flamborough Head in Yorkshire. In 1985-1987, numbers had increased to 55,000 pairs (Lloyd *et al.* 1991). Counts made in 1998-2003 put the number at over 130,000 (Harris & Wanless 2004). These totals suggest an average increase of 6% per annum for the region over the last 30 years. In Britain, the Puffin is usually considered a bird of wild and remote places. However, in 2003 there were more Puffins nesting on the North Sea coasts of Scotland and north-east England, than at the famous seabird colony of St Kilda.

Tree mallow is indigenous to England and Wales but was introduced to Scotland (Cox 2002). Although not very dense or widespread, it is well-established on Fidra, where attempts are currently being made to control it (Dave Jones *pers. comm.*). Unless similar measures are undertaken to control its spread on Craigleith, Puffin numbers there are likely to be reduced further. Tree mallow is intolerant of grazing (Gillham 1953), so consideration might be given to removing some of it and introducing rabbits to Craigleith to restrict its regeneration.

ACKNOWLEDGEMENTS

Liz Wickens, Stijn Bierman, Genevieve Jones, Morten Frederiksen, Ian Thomson, Elaine Ogston, Vicky Hughes, and Calum Leitch took part in the counts, which were funded by a contract placed with the Centre for Ecology and Hydrology by Scottish Natural Heritage. We thank the many people who have counted Puffins over many years and who deposited their data with the RSPB, Forth Seabird Group and ourselves. John Walton and Paul Morrison supplied details of the counts on the Farne Islands and Coquet Island, respectively, and John Davies improved the manuscript with his criticisms.

INVENTARISATIE VAN PAPEGAAIDUIKERS IN DE FIRTH OF FORTH, ZUIDOOST-SCHOTLAND, IN 2003

In drie kolonies in de Firth of Forth werden de broedende Papegaaiduikers in 2003 geïnventariseerd. Op het eiland May werden 69.301 bezette nestholen gevonden, waarmee het eiland de grootste kolonie in Groot-Brittannië en Ierland is. Deze populatie nam van 1970 t/m 2003 toe met een jaarlijkse gemiddelde groei van 10,9%. De aantallen op Fidra (1466 holen) groeide in 1976-2003 met een vergelijkbare snelheid, nl. 9,5% per jaar. Op Craigleith bedroeg het aantal bezette holen in 2003 (12.300) minder dan de helft van het in 1999 geschatte aantal. Deze afname lijkt veroorzaakt door de snelle uitbreiding van een exoot, *Lavatera arborea*. De geografisch te onderscheiden populatie Papegaaiduikers tussen de Moray Firth en Flamborough Head werd in 2003 geschat op 130.000 bezette holen, hetgeen overeenkomt met een jaarlijkse groei van 6% gedurende de afgelopen dertig jaar.

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