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Isle of May seabird studies in 1998

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Comments: The Isle of May is one of JNCC's Seabird Monitoring Programme key sites, and JNCC continued to fund aspects of ITE's work there in 1998 (in particular monitoring of breeding success, adult survival and food of a range of species). SNH carried out monitoring of the numbers of some species and this work will be reported separately.

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1 Summary

1 Shag numbers again increased slightly following the dramatic crash in 1994. The first egg was laid on 1 March, which was the earliest recorded start to the season, and laying continued until early July. Breeding was badly affected by severe weather in April and an apparent food shortage during the chick phase. However, productivity (0.85 young per incubating pair) was well within the normal range.

2 Kittiwakes had a late breeding season, but most pairs present built nests. The mean clutch-size (1.46 eggs per nest) was, however, below the long term average (1.67). Breeding was an almost complete failure, with the 683 pairs where success was monitored rearing a total of at most 13 chicks (0.02 chicks per pair). Many young were left unattended and adults appeared to be having problems finding food. Few birds prospected and, given the low breeding success over the last ten years, the population is likely to decline unless there is immigration.

3 All the auks had exceptionally late and relatively unproductive seasons. Heavy rain caused many puffin burrows to be flooded and breeding success (at 0.57 chicks per pair laying) was the lowest ever recorded on the Isle of May. Breeding success of guillemot (0.73 chicks per pair laying) and razorbill (0.57 chicks per pair laying) were significantly below normal. Fulmar breeding success (0.35 chicks per incubating pair) was slightly below normal.

4 The return rates of adult shag and guillemot were extremely high (93.6 and 94.6% respectively), whereas those of kittiwake (66.2%) and puffin (85.5%) were depressed.

5 Sandeels made up the bulk of the diet of young shags (98% by biomass), puffins (86%) and kittiwakes (81%). However, whereas shags were fed large sandeels, one or more years old, kittiwakes and puffins received small 0-group fish. In contrast, small Clupeidae (probably sprats) were the main item brought to young guillemots.

6 These results and more detailed behavioural data collected as part of the ELIFONTS project suggest that, particularly in the latter half of the season, sandeels in the 1-group and older age classes were less abundant than in 1997 and that many of the seabirds on the Isle of May experienced difficulties in provisioning their chicks.

2 Background

The Joint Nature Conservation Committee (JNCC) has a responsibility to advise on certain aspects of the condition of the natural marine environment. Seabirds are one of the more important components of this environment, and Britain has internationally important populations of several species. JNCC has designed a programme that will allow the numbers and breeding success of selected species of seabirds to be monitored at a range of colonies throughout the UK. In addition, selected colonies have been targeted for more detailed monitoring of reproductive performance and annual survival rates. These selected colonies are geographically spread in order to give the fullest possible coverage of British waters. The Isle of May NNR is a very suitable site in eastern Britain.

The Institute of Terrestrial Ecology (ITE) has a long-term interest in seabirds on the Isle of May. Since 1986, ITE has received NCC/JNCC support for a more formalised seabird monitoring programme. Long-term studies on numbers, breeding success, adult survival and chick food are underway on up to eight species. Due to the long period of immaturity and high annual survival rates of seabirds, it is essential that continuity of these long-term studies is maintained. As part of its Seabird Monitoring Programme, JNCC has a contract with ITE to:

a) ensure that the breeding success of fulmar *Fulmarus glacialis*, shag *Phalacrocorax aristotelis*, kittiwake *Rissa tridactyla*, guillemot *Uria aalge*, razorbill *Alca torda* and puffin *Fratercula arctica* is monitored;

b) monitor adult survival of kittiwake, guillemot, razorbill and puffin. Shag was included up to March 1994, excluded for the 1994 season but reinstated in May 1995;

c) assess food of young shags, kittiwakes, guillemots, razorbills and puffins;

d) undertake special studies on species agreed between the nominated officer and the contractor.

The development of an extremely large and concentrated industrial fishery for sandeels on the Wee Bankie off the entrance to the Firth of Forth has caused much concern. The EC has funded a three-year study into the Effects of Large-scale Industrial Fisheries On Non-Target Species (ELIFONTS) centred on the Firth of Forth. ITE has the responsibility for seabirds in this integrated project, and is carrying out fieldwork, based on the Isle of May, during 1997 and 1998. The objectives are:

- to quantify breeding parameters of three species of avian top predator in the Firth of Forth;
- to identify foraging areas of these species during the breeding season;
- to quantify diurnal and seasonal patterns of foraging activity for these species;
- to assess diurnal and seasonal variation in diet of these species.

This study (organised by Dr Sarah Wanless) links closely with, and complements, the JNCC-supported project reported here and various NERC-funded projects. Together these studies will make an important contribution to understanding the relationships between seabirds and their prey.

3 Methods

3.1 Breeding success

The standardised methods used involved minimal disturbance of birds and are described in detail by Walsh *et al.* (1995) in the *Seabird monitoring handbook for Britain and Ireland.*

3.1.1 Fulmar: The positions of apparently incubating birds in ten areas were marked on photographs on 1, 4 and 7 June. At sites where birds appeared to be incubating on all three visits, or where an egg was seen, breeding was assumed to have occurred. These sites were checked again on 12 July (to determine eggs which had hatched) and on 19 August (by J. Wilson), when those with a large chick were assumed to have been successful.

3.1.2 Shag: The positions of nests in fourteen areas were marked on photographs and the state and contents of these nests were checked weekly from 26 March until 4 August by F. Daunt. Five nests with eggs or very small chicks on 4 August were assumed to have failed, those with older chicks were assumed to have been successful.

3.1.3 Kittiwake: The positions of nests in fourteen areas were marked on photographs and the presence or absence of an incubating bird, or the number of young present at each, was checked on 30-31 May, 6-7 June, 16 July (by when most chicks would have been well grown) and 22 July, the day after the first fledged young were seen. Checks were repeated on 31 July, when only one large chick was present which was assumed to have fledged. S. Lewis made most of the checks.

3.1.4 Guillemot and razorbill: Daily checks of the state of breeding of numbered nest sites in five study plots were made from permanent hides.

3.1.5 Puffin: Breeding was very late. In each of four areas, samples of 50 burrows where an egg could be felt on 8-10 May (when most pairs had laid) were marked. These marked burrows were re-checked on 9-10 July, 7-10 days later than normal. Normally all large young present in the second check are assumed to have fledged, as are young from empty burrows where there are many droppings, moulted down and feather sheaths. However, in 1998, torrential rain, possibly compounded by food shortage, resulted in many young dying from mid-July onwards. The productivity figures were therefore corrected to take account of these losses, using a value obtained from deaths recorded in 40 burrows where chicks were being weighed every four days.

3.2 Adult survival rates

For all species, adult survival rates (perhaps better described as between-season return rates) are based on sightings of individually colour-ringed birds. The areas in which birds were originally marked were checked regularly throughout the season and adjacent areas were also searched from time to time in an attempt to find birds that had moved. Searches of the whole island were made for birds that had moved out even further afield. These latter searches are extremely time consuming, and superficially unrewarding, but they are essential if accurate estimates of survival are to be obtained.

3.3 Food of chicks

After the first young had hatched, food regurgitated by young shags and by both young and adult kittiwakes, plus loads of fish dropped by adult puffins caught in mist-nets, were collected. These samples were weighed and the fish then identified and, where possible, measured (total length to tip of tail). As most regurgitated fish were well-digested, otoliths were extracted by digesting the

samples using biological washing powder. The lengths of the fish from which they came were calculated using, for (a) sandeels, regressions derived from otoliths taken from fish of known length collected from birds on the island in 1998, and for (b) other species, relationships published in Härkönen's *Otoliths of the bony fishes of the Northeast Atlantic* (1986). Records were kept of fish brought to young guillemots and razorbills during three all-day watches and opportunistically at other times, and uneaten fish were collected from breeding ledges to assess sizes and confirm identifications.

4 Results

4.1 Breeding success

Species accounts are given in Tables 1-4 and a comparison with recent years' results is shown in Table 5.

4.1.1 Fulmar: The first egg was seen on 13 May. Breeding success was 0.35 young per incubating pair (Table 1), which was the second lowest value recorded since monitoring started in 1986. The methodology used is not designed to determine precisely when breeding attempts fail, but it appeared that losses were fairly evenly distributed between the egg and chick stage.

4.1.2 Shag: The first egg was laid on 1 March, eleven days before the previous earliest laying date recorded, in 1997. Breeding was severely disrupted by northerly gales in early April which destroyed virtually all nests on the east side of the island. Most adults then vacated the island and there was a hiatus in laying until early May. Of 159 nests initiated in the fourteen study plots, 128 had eggs laid in them. Gulls took the initial (and only) eggs laid in three nests when adults left because of our activities; these nests were not included in estimates of fledging success. A total of 104 chicks were reared in 49 successful nests, an average success of 0.85 young per pair which laid (Table 2). Breeding production based on the mean of the estimates for individual plots was lower, at 0.69, but we prefer the former estimate since five plots held only one to three nests and these were generally unsuccessful (Table 2). The estimated success (0.85) was above the long-term average (0.76, n = 13 years), but well within the 95% Confidence Interval (0.57 - 0.95) of this value.

4.1.3 Kittiwake: Breeding in 1998 was slightly later than the long-term average (Table 13); the first egg was laid on 13 May, the first egg hatched on 9 June and the earliest young fledged on 23 July. The low overwinter return rate suggested that mortality had been higher than normal and/or that some birds had taken a year off breeding. Most pairs which were present built and lined a nest, so that there was little obvious non-breeding by the adults which had returned. The mean clutch-size (1.46 per lined nest) was lower than average (1.67, n = 9 years, s.e. = 0.14). Breeding success was extremely poor, with the 683 pairs that had well-built nests raising a total of, at most, 13 young (0.02 young per pair). The mean success of the fifteen study plots was also 0.02, with the highest success (0.07) being recorded in the South Face and Cornerstone plots (Table 3). Substantial numbers of young were left unattended (Table 11).

Detailed study by Sue Lewis found that of 213 eggs laid in 115 study nests, 105 (49%) failed to hatch, 21 were addled and 84 were assumed lost to predators. Most eggs (70) were lost between 6 and 25 June. Fewer than 20% of chicks that hatched (n = 108) survived past fifteen days of age and only one definitely survived to fledging. Most chicks were lost between 26 June and 10 July, with 41% of losses occurring in the period 1-5 July. Concurrent studies indicated that adults were having trouble feeding the chicks. Although many young were eaten by gulls, food shortage seems likely to have been the ultimate cause of failure.

Breeding success of kittiwakes in 1998 was by far the lowest success recorded on the Isle of May since monitoring started in 1986. Overall the colony (estimated at 4,306 nests in 1998; SNH count) fledged a maximum of 80-100 chicks. The previous lowest estimate was in 1993 when about 200 chicks fledged.

4.1.4 Guillemot: Laying was exceptionally late with the first egg not recorded until 1 May, fourteen days later than in 1997. The median laying dates in the earliest and latest areas followed were 10 and 16 May respectively. The first young left on the night of 25/26 June. Breeding success (0.73 young leaving per pair laying) was the joint lowest ever recorded (Tables 4 and 5), and was outside the 95% Confidence Interval for the seventeen previous seasons (0.78-0.82). Much of this reduction in success was due to higher losses during the chick period (18% of young hatched compared to the usual 5-6%). Concurrent studies showed that off-duty adults spent little time at the nest-site, with the median changeover interval after a feed being less than five minutes compared to 20-30 minutes or more in most other years. There was also evidence that chicks left the colony in poor condition, with weights of well grown young being 25% lower than normal. All the available evidence pointed to adults having to work harder to provision their young and being unable to supply sufficient food for chicks to grow normally.

4.1.5 Razorbill: Breeding was later than in recent years, with the first egg being laid on 2 May. Breeding success (0.57 young leaving per pair laying) was extremely low, and well below the lower 95% Confidence Limit (0.74) of the mean for 1982-96 (0.82) (Tables 4 and 5). Most losses occurred at the egg-stage, but the loss of chicks (18%) was much higher than normal.

4.1.6 Puffin: Breeding was both extremely late and very protracted. The first fish were seen brought ashore on 5 June, fourteen days later than in 1997, and the first young fledged on 8 July. Breeding success as estimated by the second check of burrows on 9-10 July was normal (0.74 chicks per egg laid; Table 4) but torrential rain soon after resulted in many burrows becoming completely flooded. This, and probably a shortage of food, resulted in many chicks dying in the second half of July. Of 37 chicks in two of the monitoring areas where chicks were being weighed every four days, ten (27%) died in late July. Assuming similar losses in the other two plots used to monitor breeding success (which seemed extremely likely), chick production in 1998 was estimated at 0.54 chicks per pair which laid. This was unprecedentedly low compared with the long-term average of 0.81 (n = 22 years, 95% Confidence Interval 0.78-0.84). Both the peak weights attained by chicks during their development and their weights at fledging were the lowest ever recorded.

The springs and summers of 1995 and 1996 were very dry and this resulted in extremely poor vegetation growth in many colonies and severe soil erosion. Despite the extremely high rainfall in 1997, the vegetation in the puffin colonies recovered only slightly. With a second wet season in 1998, the *Holcus* grass grew well and some bare areas regained their vegetation. However, some places, notably the southern half of Burrian, remain completely unvegetated with severe soil erosion. The future of this part of the colony, containing some 1,000-1,500 burrows, must be highly uncertain.

4.2 Adult survival

Not every adult alive is seen each year, and thus the resighting rates between 1997 and 1998 of 66.2% for kittiwake, 94.6% for guillemot, 65.6% for razorbill, 85.5% for puffin and 93.6% for shag must be treated as minimum estimates of adult survival rates. Sample sizes are given in Table 6, where the results in 1998 are compared with similar figures for earlier years.

Survival of shags has been extremely high since the catastrophic wreck in early 1994 when over 80% of adults died. The rate of 93.6% for 1997-98 follows this trend. The severe gales during early April 1998, which caused severe disruption to the breeding of many species on the Isle of May, resulted in many adult shags deserting the island. Some colour-ringed shags seen before these gales were not recorded subsequently but it is, as yet, not possible to assess whether they died (though none were among the sixteen ringed shags from the Isle of May so far reported dead following these gales), or have just refrained from breeding and spent the summer elsewhere.

The resighting rate of adult guillemots known to be alive the previous year remained very high at 94.6%. An analysis of all the data back to 1982, using the programme SURGE, suggests an average survival over the period of 94.8% (s.e. 0.6%). Given that in any year 1-2% of individuals are not seen, survival between 1997 and 1998 was probably above average.

The resighting rate of kittiwake (66.2%) was the lowest recorded in recent years. It will be interesting to see whether mortality over the 1997-98 winter was high or if birds had taken a year off breeding and did not return to the Isle of May in 1998.

An up-to-date SURGE assessment of the survival estimate of breeding puffins in recent years has estimated the following-

	Survival probability	*Probability of a bird being seen*
1993-4	0.960	0.954
1994-5	0.930	0.931
1995-6	0.927	0.973
1996-7	0.945	0.945

The survival estimate for the final year of this analysis is the same as the resighting rate as more years' data are needed to allow for birds not seen. The preliminary, minimal, estimate of survival over the 1997/98 winter of 0.855 is unexpectedly low. Again, time will tell whether or not survival over this period was indeed low.

During 1998, the following adult birds were colour-ringed: two shags, 37 kittiwakes, eight puffins and twelve guillemots.

4.3 Food of young

4.3.1 Shag: The 39 samples from shags were composed almost entirely of sandeels *Ammodytes marinus* (98%), the only other item being three butterfish *Pholis gunnellus* (8-15 cm long) and a single prawn *Crangon* sp. (Table 7). Of the 429 sandeel otoliths examined, 400 (93%) came from fish one year or more old.

These results suggest that shags were, as usual, depending almost entirely on sandeels during June and July. However, a separate programme of work carried out by Francis Daunt indicated that the diet of adult males was much more varied. A total of 23 birds with chicks were water off-loaded on their return to the colony at the end of a feeding trip. Of the 22 samples with prey remains, fifteen (68%) contained sandeels and fourteen (64%) had other species, the commonest being butterfish (50%) and dragonet *Callionymus lyra* (23%). Smaller numbers had flatfish, probably long rough dab *Hippoglossoides platessoides,* Clupeidae, wrasse *Labridae,* eelpout *Zoarces viviparus*, bull-rout *Myoxocephalus scorpius* and Gadidae. Load weights were lower than in earlier years, and radio-tracking indicated that the adults were working extremely hard.

Thus there was some evidence that shags were short of food, particularly towards the end of the season, although this did not result in markedly low breeding success.

4.3.2 Kittiwake: Sandeels were the commonest food (97% by number of 2,356 otoliths) of kittiwakes and contributed 81% by weight of the total regurgitations (Table 7). Approximately 97% of the sandeels in regurgitates were 0-group fish 6-8 cm long (n = 2,284 otoliths examined). Nineteen regurgitates had sprat *Sprattus sprattus* 7-9 cm long (60 otoliths, mean fish length 81.7±s.e.0.9 mm). Three whiting *Merlangius merlangus* were presumably trawler discards. Other material recorded were polychaetes (two samples) and probable sewage waste (three).

4.4.3 Auks: Of 1,340 fish delivered to young guillemots, 343 (26%) were sandeels, mostly 8-13 cm long. However, the bulk (74%) of fish brought in were Clupeidae (Table 8). Of eight clupeids retrieved from birds, six were sprats (7-10 cm) and two were herring (14-15 cm). The average weight of a prey item (calculated from lengths) was 4.4 g. In biomass terms, clupeids made up 79% of the diet, but, in contrast to other years when clupeids were the dominant prey, the individual fish were small. Razorbill loads brought to chicks were mainly made up of sandeels (82% of 88 loads) (Table 9). The remaining loads had one to two medium clupeids.

By number, sandeels made up 94% of the diet of young puffins (Table 10), with the proportion in biomass terms reduced to 86%. The mean length of sandeels was 62 mm, and only 39 (1.3%) were longer than 10 cm. Puffins therefore fed their young predominantly on 0-group sandeels. Many of the Clupeidae were small and difficult to identify, but the bulk of those identified were sprat. The mean load size of 8.2 g was significantly below normal (mean of 25 years = 9.3 g, 95% Confidence Interval 9.0-9.6) and, due to their small size, the number of fish per load (10.7) was by far the highest recorded since data started to be collected in 1972. The low breeding success and very low peak and fledging weights of chicks suggest that puffins were short of food late in the season.

5 The future

5.1 During the 1970s and for most of the 1980s, conditions were very favourable for seabirds in the North Sea, since populations of most species, excluding terns, increased greatly. Since the late 1980s, monitoring has shown drops in numbers, and to a lesser extent, breeding success, of several species. The reasons for these changes are not clear but, at least for the guillemot, change started in the north and gradually moved south. Population declines started significantly earlier and were fastest in northern colonies. Numbers of auks are now increasing again. A run of unproductive years by kittiwakes, a reduced level of colony return of experienced breeders and the apparent dearth of prospecting birds in the colony causes concern for the future breeding population.

5.2 Long-term studies, partly funded under JNCC's integrated Seabird Monitoring Programme, in the Firth of Forth have shown a much reduced survival of adult puffins in the 1980s and early 1990s and of adult shags in 1994, low recruitment of some cohorts of young guillemots, poor breeding and non-breeding of kittiwakes, delayed (and irregular) breeding of shags, reduction in the intake of young guillemots and sporadic food shortage in several species. Neither the ultimate nor the proximate factor(s) causing these changes have been determined but studies continue.

5.3 An industrial fishery for sandeels near the Firth of Forth started in 1990. In 1991, several Danish fishing vessels were trawling for sandeels over the Wee Bankie to the north-east of the Isle of May. Many more were reported to be fishing there in 1992, and in 1993 the reported

catch was 115,000 tonnes (ICES Working Group report CM 1995/ Assess:5). An additional 72,000 tonnes came from the fishery area immediately south of the Isle of May. Fewer boats fished the area in 1994, apparently because sandeels were available closer to Denmark. In 1995, Danish vessels were fishing in the entrance to the Firth of Forth early in the season but then moved elsewhere. Some Scottish vessels have been reported fishing for sandeels off eastern Scotland and landing their catches in Denmark. The Danish fleet returned to the Wee Bankie in 1996, and that summer saw a high profile protest by the Greenpeace ship 'Sirius', which spent much time around the Wee Bankie and the Isle of May. The 'Save the Wee Bankie' campaign got much TV and other media attention and the Isle of May is now well known to a much wider public. The Danish fleet continued to fish for sandeels on the Wee Bankie in 1997 and 1998.

5.4 The summer of 1997 saw the start of the two-field-season multi-institute project ELIFONTS (Effects of Large-scale Industrial Fisheries On Non-Target Species). This is part-funded by the EC Directorate General XIV (Fisheries). The objectives relevant to seabirds are

5.4.1 To determine the availability of lesser sandeels to top predators (grey seals, kittiwake, guillemot, and shag) in the Moray Firth and Firth of Forth.

5.4.2 To investigate the effects of between- and within-year variations in sandeel availability on the foraging behaviour, foraging efficiency, diet and reproductive output of top predators and on the diet of predatory fish.

5.4.3 To evaluate the potential impact of a large-scale fishery on top predators in the Firth of Forth and to examine the generality of the results.

Substantial progress has been made. The results coming from this JNCC-funded contract are crucial in interpreting the ELIFONTS detailed study and for putting the present situation into perspective.

5.5 Although kittiwakes on the Isle of May have had low breeding success for the past five to six years, 1998 was by far the worst year yet, and there are now signs that the population is declining. Shags too have had poor years, but these have been when breeding was very late. Laying was early in 1998 and we would have anticipated a much higher breeding success. All three auks had low breeding success, especially marked at the chick stage; this, and the low weights (and calculated calorific value) of feeds brought to the chick and of chicks themselves, suggest that adults had problems feeding them. Overall, 1998 was the poorest season for Isle of May seabirds since ITE's studies started in 1972.

5.6 There is, as yet, no direct evidence that industrial fishing in the North Sea has an adverse effect on the availability of food for seabirds. Whether or not such a fishery continues to develop, it is imperative that the monitoring of seabird breeding, numbers (carried out by SNH) and recruitment, as well as the food of seabirds on the Isle of May, continues so that we can determine the factors controlling the numbers of seabirds in the North Sea and so assess the importance of the many anthropogenic influences on these seabird populations.

6 Acknowledgements

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7 Papers on Isle of May seabirds published or in press since the last report

Catchpole, E.A., Freeman, S.N., Morgan, B.J.T., & Harris, M.P. 1998. Integrated recovery/recapture data analysis of shags. *Biometrics, 54*: 33-46.

Finney, S.K., Wanless, S., & Harris, M.P. In press. The effect of weather conditions on the feeding behaviour of a diving bird, the common guillemot *Uria aalge*. *Journal of Avian Biology.*

Harris, M.P., Freeman, S.N., Wanless, S., Morgan, B.J.T., & Wernham, C.V. 1997. Factors influencing the survival of puffins *Fratercula arctica* at a North Sea colony over a 20 year period. *Journal of Avian Biology, 28*: 287-295.

Harris, M.P., & Wanless, S. 1997. Inland nesting by razorbills. *Scottish Birds, 19*: 121-122.

Harris, M.P., & Wanless, S. 1997. Successful rehabilitation of oiled guillemots *Uria aalge*. *Sula, 11*: 183-185.

Harris, M.P., & Wanless, S. 1997. Sandeels, brood neglect and breeding success in the kittiwake *Rissa tridactyla* over an 11 year period. *ICES Journal of Marine Science, 54*: 615-623.

Harris, M.P., Wanless, S., & Elston, D.A. 1998. Age-related effects of a non-breeding event and a winter wreck on the survival of shags *Phalacrocorax aristotelis*. *Ibis, 140*: 310-314.

Wanless, S., Bacon, P.J., Harris, M.P., Webb, A.D., Greenstreet, S.P.R., & Webb, A. 1997. Modelling environmental and energetic effects on feeding performance and distribution of shags *Phalacrocorax aristotelis*: integrating telemetry, geographical information systems and modelling techniques. *ICES Journal of Marine Science, 54*: 524-544.

Wanless, S., Barton, T.R., & Harris, M.P. 1997. Blood haematocrit measurements in four species of North Atlantic seabird in relation to levels of infestation by the tick *Ixodes uriae*. *Colonial Waterbirds, 20*: 540-544.

Wanless, S., Gremillet, D., & Harris, M.P. 1998. Foraging activity and performance of shags *Phalacrocorax aristotelis* in relation to environmental characteristics. *Journal of Avian Biology*, 29: 49-54.

Wanless, S., & Harris, M.P. 1997. *Phalacrocorax aristotelis*: shag. *BWP Update, 1*: 3-13.

Wanless, S., & Harris, M.P. 1997. Successful double-brooding in European shags. *Colonial Waterbirds, 20*: 291-294.

Wanless, S., Harris, M.P, Burger, A.E., & Buckland, S.T. 1997. Use of time-at-depth recorders for estimating depth utilization and diving performance of European shags. *Journal of Field Ornithology, 68*: 547-561.

Wanless, S., Harris, M.P., & Greenstreet, S.P.R. In press. Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. *ICES Journal of Marine Science.*

Table 1 Breeding success of fulmars on the Isle of May in 1998

Area	*Incubating birds*	*No. probably hatched*	*Young fledged*
1. Cleaver	8	5	2
2. Pilgrim's Haven	1	0	0
3. Cornerstone	9	3	2
4. Loch (S)	44	28	14
5. Greengates	26	25	14
6. Horse Hole	5	4	2
7. Rona	0	0	0
8. Tarbet	19	11	7
9. Low Light	7	4	1
10. Colm's Hole	1	0	0
Total	*120*	*80*	*42*
Overall mean			*0.35 fledged/pair*

Notes: Incubating birds were those sitting tight on three checks or where an egg was seen. Chicks present on 19 August were assumed to have fledged. The final check was made by J. Wilson.

Table 2 Fledging success of shags on the Isle of May in 1998

	Area	*Total no. incubated*	*No. nests with 1, 2 or 3 young fledged*			*No. of other nests*	*Total no. of young fledged*	*Mean no. of young fledged per incubated nest*
			1	*2*	*3*			
3.	Maidens	15	1	3	2	6[+]	13	0.87
4.	South Horn	1	0	0	0	0	0	0.00
5.	Chatterstanes	3	0	1	0	2	2	0.67
16.	Pilgrims Haven (S)	14	5	3	0	5	11	0.79
6.	Colony A	1	1	0	0	1	1	1.00
7.	South Face	1	0	0	0	0	0	0.00
8.	Mill Door (N)	10	4	1	2	1	12	1.20
9.	Mill Door (S)	14	3	2	1	3	10	0.71
10.	Bishop Cove	2	0	0	0	0	0	0.00
8.	Horse Hole	22	2	5	3	2	21	0.95
15.	North Horn	13	1	3	1	3*	10	0.77
12.	Tarbet	8	1	1	2	3	9	1.12
13.	Low Light	10	3	1	0	4	5	0.50
14.	Colm's Hole (N)	11	3	3	1	4	12	1.09
Totals		*125*	*24*	*23*	*12*	*34*	*106*	***0.85***
Mean of areas ±s.e.								***0.69 ±0.1***

Notes: The nesting success in 1997 was 0.96 young per incubated nest. This takes account of an unexpectedly high survival of the latest nests and replaces the estimate given in the 1997 report. In 1998, plots 1 and 2 had no nests. Nests were checked until 4 August. Five nests with eggs or very small chicks then are assumed to have fledged.

[+]Includes two nests with single eggs lost due to human disturbance.

*Includes one nest with single egg lost to human disturbance.

Table 3 Breeding success of kittiwakes on the Isle of May in 1998

Area	*Completed nests*	*Trace nests*	*Other pairs with site*	*No. of completed nests with 0, 1 or 2 fledged young*			*Total young produced*[1]	*Fledging success per completed nest*
				0	*1*	*2*		
1. Cleaver	36	0	3	36	0	0	0	0
2. Pilgrim's Haven	12	0	3	12	0	0	0	0
3. South Face	27	0	1	25	2	0	2	0.07
4. Colony 4	73	2	14	70	2	1	4	0.05
5. Cornerstone	74	0	4	70	3	1	5	0.07
6. Loch (S)	54	0	3	54	0	0	0	0
7. Loch (N)	91	0	10	91	0	0	0	0
8. Greengates	53	0	1	53	0	0	0	0
9. Bishop's Cove	53	0	9	52	1	0	1[1]	0.02
10. Horse Hole	6	0	0	6	0	0	0	0
11. Iron Bridge	44	0	2	44	0	0	0	0
12. Rona	40	1	0	40	0	0	0	0
13. Tarbet	84	2	13	84	0	0	0	0
14. Low Light	17	0	0	17	0	0	0	0
15. Colm's Hole	19	0	1	18	1	0	1	0.05
Totals	*683*	*5*	*64*	*0*	*9*	*2*	*13*	-
Mean breeding success								***0.02***
SE								***0.01***

Note: [1]A single large chick present at the last check was assumed to have fledged.

Table 4 Breeding success of auks on the Isle of May in 1998

Species	*Area*	*Pairs laying*	*Young hatched*	*Young fledged*	*Young leaving per pair*
Guillemot	Dense	282	238	217	0.77
	Hide/White	89	73	66	0.74
	Colony 4	238	199	176	0.74
	South	49	42	33	0.67
	Cornerstone	194	152	138	0.71
	Mean ± S.E.				*0.73±0.01*
Razorbill	Hide/White	19	12	11	0.58
	Colony 4	43	27	20	0.47
	South	13	9	8	0.62
	Cornerstone	59	45	37	0.63
	Mean ± S.E.				*0.57±0.04*
Puffin	Lady's Bed	46	?	35	0.76(0.56)
	Kirkhaven	46	?	37	0.80(0.58)
	Burrian	46	?	29	0.63(0.46)
	Rona	41	?	32	0.78(0.57)
	Mean ± S.E.				*0.74±0.04*
					(0.54±0.02)*

Note. *After allowing for 27% mortality late in the season (see text).

Table 5 Breeding success (young reared per pair breeding) of some seabirds on the Isle of May, 1989-98

Species	*1989*		*1990*		*1991*		*1992*		*1993*	
Fulmar	0.54	(93)	0.24	(66)	0.42	(100)	0.47	(129)	0.44	(121)
Shag	1.09	(234)	0.30	(154)	1.06	(187)	0.87	(181)	0.21	(80)
Kittiwake	1.11	(1,327)	0.17	(1,095)	0.27	(1,172)	0.61	(1,062)	0.07	(1,034)
Guillemot	0.85	(757)	0.78	(748)	0.81	(754)	0.85	(745)	0.76	(797)
Razorbill	0.74	(97)	0.76	(100)	0.72	(104)	0.86	(105)	0.72	(119)
Puffin	0.88	(164)	0.66	(176)	0.78	(153)	0.87	(184)	0.69	(182)
	1994		*1995*		*1996*		*1997*		*1998*	
Fulmar	0.47	(122)	0.48	(126)	0.44	(135)	0.37	(136)	0.35	(120)
Shag	0.68	(74)	0.84	(131)	1.05	(105)	0.96*	(109)	0.85	(125)
Kittiwake	0.16	(861)	0.40	(874)	0.56	(825)	0.40	(822)	0.02	(683)
Guillemot	0.79	(775)	0.81	(805)	0.82	(786)	0.77	(842)	0.73	(852)
Razorbill	0.69	(134)	0.62	(143)	0.63	(140)	0.71	(132)	0.57	(134)
Puffin	0.85	(189)	0.84	(180)	0.78	(173)	0.65	(166)	0.54	(179)

Notes: The number of pairs followed is given in brackets. Details of method etc. can be found in this and previous reports to JNCC.
*Differs slightly from that given in the 1997 report since later checks indicated that more than anticipated of the late chicks survived to fledging.

Table 6 Annual resighting rates of adult seabirds on the Isle of May, 1988-98

Species	*No. seen in 1997*	*No. alive in 1998*	*% survival*				
			1997-98	*1996-97*	*1995-96*	*1994-95*	*1993-94*
Kittiwake	130	86	66.2	78.7	75.8	72.7	79.5
Guillemot	373	353	94.6	91.8	88.9	95.6	95.0
Razorbill	29	19	65.6	82.1	56.6	92.6	84.5
Puffin	220	188	85.5	90.7	90.1	93.0	93.1
Shag	171	160	93.6	91.1	93.6	?	?
			1992-93	*1991-92*	*1990-91*	*1989-90*	*1988-89*
Kittiwake			80.8	80.7	84.2	78.7	90.9
Guillemot			95.0	93.3	91.0	94.9	92.4
Razorbill			91.5	89.8	79.6	75.0	90.5
Puffin			84.0	86.8	71.4	63.3	85.2
Shag			79.6	79.9	82.8	78.7	90.9

Notes: Only birds that had definitely bred at least once are included. Directly comparable figures for adult survival in earlier seasons are given. These have not been corrected for missing birds seen in later years, and so are serious under-estimates of actual survival rates. These figures should not be used for population dynamics calculations without consultation with M.P. Harris. Details of earlier estimates are given in previous reports to NCC/JNCC.

Table 7 Food of young kittiwakes and shags on the Isle of May during the chick-rearing period in 1998

	Kittiwake	*Shag*
No. of regurgitations	110	39
Range of dates	11 June-14 July	13 May-1 August
Total weight (g)	2,299	1,489
% regurgitations with sandeels	89	95
with Gadidae	3	0
with Clupeidae	17	0
% (by weight) of sandeels in sample	81	98
% (by numbers) of sandeels in sample	97	99
Lengths of majority of sandeels (cm)	6-8	10-15
Non-sandeel remains identified	Whiting (3,13.5-18.5 cm)	Butterfish (3, 8-16 cm)
	Polychaetes (2)	*Crangon* sp.(1)
	Probable sewage waste (3)	

Notes: Samples collected from chicks or adults during the chick-rearing period. Counts and lengths of fish in samples were based on otoliths retrieved from the regurgitations.

Table 8 Food of young guillemots on the Isle of May in 1998

	Number of sandeels				*Number of Clupeidae*			*Squid*
	minute/larval	*small*	*medium*	*large*	*small sprat*	*medium sprat*	*large herring*	
Mean length (cm)	6	8	12	15	8	10	14	
All-day watches								
21 June	0	77	73	15	132	54	14	0
28 June	0	14	10	2	63	38	4	1
5 July	0	7	5	1	47	26	8	0
3 June-26 July	9	84	50	5	534	68	9	0
Totals	***9***	***182***	***138***	***23***	***776***	***186***	***35***	***1***

Note: Lengths were based on visual estimates against the bird's bill checked against samples of dropped fish collected from the breeding ledges.

Table 9 Food of young razorbills on the Isle of May in 1998

	Single sandeel			*Several sandeels*				*Clupeidae*
	large	*medium*	*small*	*large*	*medium*	*small*	*tiny*	
All-day watches								
21 June	12	3	1	1	11	17	5	6
28 June	0	1	0	1	3	4	0	5
14 June-20 July	2	1	1	1	1	7	0	5
Totals	***14***	***5***	***2***	***3***	***15***	***28***	***5***	***16***

Notes: Figures are number of loads of various types of food.

Table 10 Food of young puffins on the Isle of May, 13 June to 31 July 1998

	Sample size	*Mean*	*S.E.*
a) Load weight (g)	318	8.25	0.22
b) No. of fish per load	318	10.66	0.30
c) Numbers and lengths of fish (mm)			
Sandeels *Ammodytes* sp.	2,950	62.5	0.24
Herring *Clupea harengus*	13	73.0	1.25
Sprat *Sprattus sprattus*	69	83.1	1.01
Clupeidae	12	60.2	5.58
Cod *Gadus morhua*	4	47.5	3.23
Gadidae	6	42.5	4.48
Whiting *Merlangius merlangus*	4	50.2	8.28
Rockling	55	37.3	0.91
Saithe *Pollarchius virens*	1	58.0	
Unidentified	17	37.7	1.08

Table 11 Kittiwake broods left unattended on the Isle of May, 1986-98

Year	*% broods of one young unattended*	*% broods of two young unattended*
1986	1	7
1988	31	66
1989	13	32
1990	21	45
1991	2	13
1992	13	28
1993	12	31
1994	1	19
1995	3	14
1996	7	27
1997	14	42
1998	23	63

Note: Figures are percentage of kittiwake broods of one and two chicks which had no adults present during daily checks in the middle of the day. Figures are normally based on 50-200 broods in the same areas each year and are the means of daily checks made between the dates the first neglected chick is noted and the start of fledging in the areas. (Details of methods are given in Wanless & Harris, 1989. *Scottish Birds, 15*: 156-161.). In 1998 this was difficult due to the failure of most broods, and the figures are the means of checks of 50-120 broods on 13 dates between 10 and 23 July.

Table 12 Percentage of sandeels (by weight) in the diet of young seabirds on the Isle of May, 1987-98

	1987	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Shag	100	98	100	95	100	97	99	86	85	99	100	98
Kittiwake	95	94	95	86	50	61	63	81	86	81	94	81
Guillemot	81	41	74	24	74	53	17	19	78	44	79	21
Puffin	77	85	89	96	87	86	46	57	50	88	86	86

Notes: Dates and sample sizes can be found in the contract reports for respective years.

Table 13 Kittiwake first-egg dates and clutch-sizes on the Isle of May, 1986-98

Year	*First date egg seen*	*Mean clutch-size (no. of eggs)*
1986	9 May	no data
1987	4 May	no data
1988	6 May	no data
1989	27 April	2.04
1990	2 May	1.82
1991	6 May	1.86
1992	30 April	1.83
1993	4 May	1.78
1994	17 May	0.86
1995	16 May	1.61
1996	24 May	1.13
1997	10 May	2.03
1998	13 May	1.46

Note: 1998 data collected by S. Lewis.