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Isle of May seabird studies in 2006

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Summary

Fortunes for Isle of May seabirds were very mixed in 2006. Of the six species studied intensively, European shags had a good season, breeding success of northern fulmars, black-legged kittiwakes, Atlantic puffins and razorbills was similar to the long-term average, and common guillemots had their worst ever breeding season. Return rates were also fairly normal for all species except common guillemots for which the value was very low. Conditions early in the season appeared to be poor with colony attendance in many species being rather low. Although lesser sandeels remained the main food of young Atlantic puffins, razorbills and black-legged kittiwakes, common guillemots fed their young mainly on clupeids, while European shags brought in a wide variety of bottom-living fish. Very few 1 group sandeels were present in food samples during the chick-rearing period. Feeding conditions seemed to deteriorate markedly at the end of the season with black-legged kittiwakes and Atlantic puffins being particularly badly affected. 2006 was also notable for the marked increase of snake pipefish in the diet of many of the seabirds.

- Northern fulmar breeding success (0.44 chicks per incubating pair) was an improvement on 2005 and close to the long-term average.
- In contrast to most other species, European shags began breeding earlier than in 2005 and had a productive season. Breeding success was 1.22 chicks per pair and the shag was the only species for which productivity was above the long-term mean. Following a major wreck early in 2005, over-wintering survival appeared much improved in 2006, with an 83% return rate that was close to the long-term mean. As in the previous two years, the prey eaten was unusually varied with sandeels making up only 53.4% by mass of the diet. The sandeels that were recorded were fairly evenly split between 0 group and the older (1+ group) fish that are normally taken.
- Black-legged kittiwakes had a very late season with only 2005 being later. Breeding success was below average (0.47 chicks per completed nest) but within the long term confidence intervals. However, there were indications that feeding conditions at, and just after, fledging deteriorated and that post fledging survival was probably low. Adult return rate (80.9%) was close to the long-term mean. The proportion of sandeel in the diet was lower than normal particularly in terms of the contribution by biomass which was only 63%.
- Common guillemots had their poorest breeding season on record with only 0.41 chicks leaving per pair laying. As in 2004 and 2005, many chicks were left unattended. Surprisingly few were taken by gulls, more were killed by other guillemots and razorbills. Return rate of adults was very low (86.9%) with only 2005 being lower. Adults fed their chicks mainly on sprats with small gadoids being the main alternative. Sandeels made up only 4% of the diet by mass. Chicks grew slowly and all the evidence suggested that feeding conditions were poor.
- Razorbill breeding was late and but breeding success (0.62 chicks leaving per pair) was close to the long-term average. Adult return rate (88.2%) was higher than the long-term average. Chicks were fed mainly 0 group sandeels.
- Atlantic puffins had another late breeding season. Breeding success improved on the previous two years at 0.78 chicks per pair, which was similar to the long-term mean. However, just as with kittiwakes there was evidence that conditions deteriorated at the end of the season with late hatching chicks showing slower growth rates and failing to reach the sea successfully. Chicks were mainly fed 0 group sandeels (90% by number, 90% by biomass). Adult return rate (81.8%) was a little below normal.

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1 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 as full a coverage as possible of British waters; the Isle of May NNR is the chosen site in eastern Britain.

The Centre for Ecology and Hydrology (CEH, formerly known as ITE) has had a long-term interest in seabirds on the Isle of May. Since 1986, CEH has received NCC-CSD/JNCC support for a more formalised seabird monitoring programme. Long-term studies on numbers, breeding success, adult survival, and chick food are carried out 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 CEH to:

- a) ensure that the breeding success of northern fulmars *Fulmarus glacialis*, European shags *Phalacrocorax aristotelis*, black-legged kittiwakes *Rissa tridactyla*, common guillemots *Uria aalge*, razorbills *Alca torda* and Atlantic puffins *Fratercula arctica* is monitored;
- b) monitor adult survival of black-legged kittiwakes, common guillemots, razorbills and Atlantic puffins. Monitoring of European shag adult survival was also included up to March 1994, was then excluded for the 1994 season, but was reinstated in May 1995;
- c) assess food of young European shags, black-legged kittiwakes, common guillemots, razorbills and Atlantic puffins; and
- d) undertake special studies on species agreed between the nominated officer and the contractor.

Soon after the Seabird Monitoring Programme (SMP) on the Isle of May was initiated, the Danish industrial sandeel fishery started to use the fishing grounds on the Wee Bankie, Marr Bank and Scalp Bank. These lie 30-50 km east of the island and are known to be important feeding areas for many seabirds during the breeding season. Considerable concern has been expressed about the potential impact of this fishery on the seabirds in the area. In December 1999, EU Fishery Ministers agreed a ban on fishing for sandeels, effective for 2000, in 20,000 square kilometres of sea off eastern Scotland (including the Wee Bankie grounds) and northeast England. Results from the 2000 season provided circumstantial evidence that the presence of an industrial fishery on the Wee Bankie might be having an adverse effect on some components of the Isle of May seabird community. In 2004, seabirds on the Isle of May did particularly poorly, despite the ban still being in operation. Continued monitoring of the Isle of May seabirds is vital to assess their performance, and in particular to determine whether 2004 was a one-off event or a temporary setback in the recovery recorded in some species since the fishery closure.

2 Methods

2.1 Breeding success

The standardised methods used involved minimal disturbance of birds and are described in detail in Walsh *et al* (1995).

Northern fulmar

The positions of apparently incubating birds in nine areas were marked on photographs on 28 May, 1, 4 and 7 June. At sites where birds appeared to be incubating on three consecutive visits, or where an egg was seen, breeding was assumed to have occurred. These sites were checked again on 17 July to determine those that had hatched eggs. A final check was made on 21 August, when chicks present were assumed to have fledged successfully.

European shag

The positions of nests constructed in 12 areas were marked on photographs and the state and contents of these nests were checked weekly from 25 April until 21 August. Medium-sized and large young still present on 21 August were assumed to have fledged successfully. Success was estimated both by averaging across the plots and summing over plots.

Black-legged kittiwake

The positions of nests in 17 areas were marked on photographs and the presence or absence of an incubating bird, or the number of young present at each, was noted. Because of the long-term decline in kittiwake numbers on the Isle of May, the extent of the plots at Greengates and Cornerstone were increased in 2005 with new plots also put in place at South Horn and Hide Face and these were continued in 2006. Checks of nests were made on 14 and 20 June when regular checks of sample areas showed that most pairs had constructed nests. The first young was seen flying on 1 August and a complete check of chicks was made on 2 August. Further checks of nests with small chicks then were made on 5, 7 and 21 August. Chicks still alive on 21 August were assumed to have fledged. Successes are given averaged across the plots and summed over the plots.

Common guillemot and razorbill

Daily checks of the state of breeding of numbered nest-sites in five study plots were made from permanent hides.

Atlantic puffin

Samples of 50 burrows where an egg was present were staked in each of four areas on 3-6 May (by when most pairs had laid). The staked burrows were re-checked on 15-16 July at the start of fledging. Normally any young present at this time are assumed to be going to fledge successfully and empty burrows where there are many droppings, moulted down and feather sheaths are also assumed to have been successful. However, from intensive work involving frequent checks of burrows being carried on in 2006, we were aware that there was considerable mortality of puffin chicks after the date the monitoring check was made and thus that our figure over-estimated success. We

therefore applied a correction factor to the monitored burrows, based on the percentage of chicks in the study burrows that were lost between 15-16 July and fledging.

2.2 Adult survival rates

Estimates of adult survival rates were based on sightings of individually colour-ringed birds and are therefore, strictly speaking, return rates. The areas in which birds were originally marked were checked regularly throughout the season and adjacent areas were searched from time to time in an attempt to locate any individuals that had moved. Searches were periodically made of the whole island for birds that had moved out of the study areas. These latter searches are very time-consuming, and superficially unrewarding, but are essential if accurate estimates of survival are to be obtained. Observations on the survival of adult Atlantic puffins were concentrated at Little Hole (where most burrows are individually numbered). As in recent years, the area used for monitoring survival of adult black-legged kittiwakes included East Tarbet, Rona (North Horn Gully), Low Light Gully, Little Hole, Cornerstone and its nearby cliffs.

2.3 Food of chicks

Food regurgitated by young European shags, young black-legged kittiwakes and adults of both species feeding young, and loads of fish dropped by adult Atlantic puffins caught in mist-nets were collected. Regurgitates and food loads were weighed, fish identified and, where possible, measured (total length, snout to tip of tail). Fish otoliths were extracted from regurgitates, identified and measured. The lengths of the fish from which they came were calculated using regressions derived from the otoliths of fish of known length where possible collected from birds on the island in 2006, otherwise from previously published relationships. Observations were made of fish brought to young common guillemots and razorbills during four all-day watches, as well as opportunistically on most other days throughout the chick-rearing period. Uneaten fish were collected from breeding ledges to confirm identifications and size assessments of common guillemots' diet. Fish sizes for razorbills were assessed against the bird's bill but were essentially orders of size as it was not possible to collect samples directly from this species.

3 Results

3.1 Breeding success

Appendix 1 provides species summaries in Tables 1- 4 and a comparison with recent years' results in Table 5. Long-term averages presented do not include the current year.

Northern fulmar

The first egg was seen on 17 May. This year saw an improvement over the previous two years with breeding success at 0.44 (Figure 1). This is within the 95% Confidence Intervals for the long-term average between 1986-2005 (0.40, CI=0.36-0.45). The methodology used is not designed to determine when breeding attempts fail, but losses appeared to have been more-or-less equally divided between the egg and chick periods.

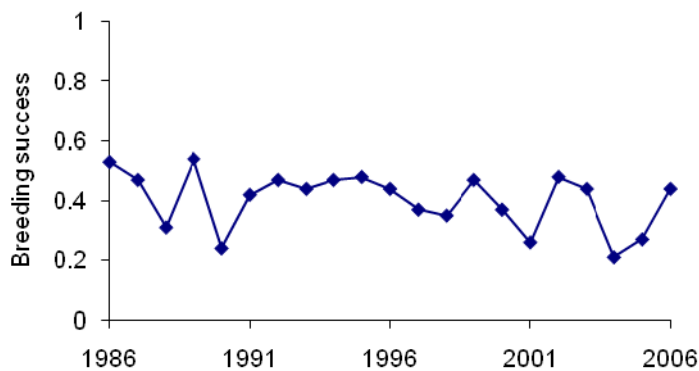


Figure 1. Breeding success (young reared per pair breeding) of Northern fulmar on the Isle of May 1986 – 2006

European shag

There was a major mortality of shags in early 2005 which resulted in only 42 pairs laying in the study plots. In 2006 there was a recovery with numbers in the plots approximately doubling but numbers were still well short of the 103 in 2004 (itself a poor year) and 156 in 2003.

Breeding was early compared to 2005 with the first egg laid on 25 April (compared with 6 May in 2005 and the long-term average of 11 April between 1986-2005). Of 87 nests built in the study plots, 81 pairs laid and 57 raised a total of 99 chicks to fledging. Productivity was high (1.22 chicks per pair laying or 1.14 per nest built) (Figure 2). The former estimate was well above the 95% Confidence Interval for the 1986-2005 average (0.90, CI=0.63-1.16).

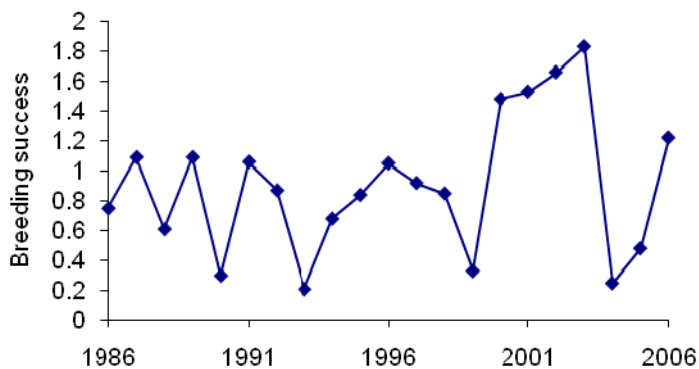


Figure 2. Breeding success (young reared per pair breeding) of European shag on the Isle of May 1986 – 2006

Black-legged kittiwake

Timing of breeding of black-legged kittiwakes in 2006 was very late with only 2005 being a later season. The first courtship feed was not observed until 15 May and the first egg not seen until 27 May. The first chick was recorded on 23 June and the first young fledged on 1 August. The mean clutch size, including complete nests where no eggs were laid, was 1.54 eggs, which is lower than recent years (Table 13). Only one clutch of three eggs was recorded in the 353 nests checked for clutch-size.

Mean breeding success in 2006 was 0.46 (\pm se 0.05) chicks per completed nest, averaged across the plots, 0.47 after pooling areas (Figure 3). This value was within the 95% Confidence Interval for the 1986-2005 average but below the long-term average (0.57, CI=0.38-0.75) and well below that in 2005 (0.85). The total number of pairs breeding in the study plot (613) was down on 2005 (675) but still higher than the previous five years.

Although overall breeding success appeared reasonable, the condition of chicks at fledging appeared to be very poor due to a rapid deterioration in feeding conditions at the end of the season. This coincided with a dramatic increase of pipefish and large numbers of adults and chicks were seen with pipefish tails hanging out of their bills and nests were littered with discarded pipefish. A check of the beach at Pilgrims Haven on 6 August (5 days after the first fledgling) revealed 26 dead kittiwake chicks near fledging. Some well-grown but weak-looking chicks that were still in the nest in early August were still present two weeks later while other nests contained dead chicks. A visit to the island in late August found 10-15 kittiwake fledglings sitting on the Mill Door loch feeding on floating insects, and there were numerous dead fledglings along the tide line. Thus it appears that many juveniles died soon after fledging and consequently the 2006 year class was lower than that indicated by the figure for breeding success given above.

The first neglected broods were noted on 10 July. The proportion of broods of both one and two which were deserted increased gradually after this. Neglected broods of one increased from 2% up to 66% by the time of the first fledging while neglected broods of two increased steadily from 11% to 90%, the average daily rates of unattended chicks were 19.5% and 38.7% for broods of one and two chicks, respectively. No brood of 3 young fledged on the island.

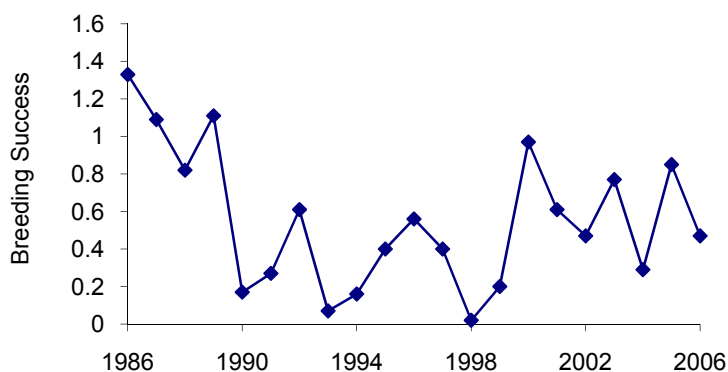


Figure 3. Breeding success (young reared per pair breeding) of black-legged kittiwake on the Isle of May 1986 – 2006

Common guillemot

Breeding numbers were slightly depressed with a total of 932 pairs laying in the study plots compared with 945 in 2005.

The first guillemot egg was seen on 2 May, the second latest date recorded on the Isle of May. The first young left on the night of 27-28 June. Breeding success (0.39 and 0.41 young per pair laying for the plot average and summed total, respectively; Figure 4) was by far the lowest ever recorded on the Isle of May. The previous lowest success was 0.51 in 2004. Although the average hatching success (84%) was close to the long-term average (83%), chick success at 49% was dramatically reduced from the normal 90%.

Normally, one member of the pair is always present in the colony to guard the chick. However, in recent years some chicks have been left unattended, suggesting that adults were finding it hard to find food, and this was very obvious in 2006. Surprisingly, such neglected chicks were rarely eaten by gulls, even though gulls came onto the ledges to pick up deserted/addled eggs and fish that had been dropped. Rather, it was clear that chicks were more likely to be killed by other guillemots (or occasionally razorbills) particularly if they wandered into neighbouring territories, or just to die on the site, apparently of starvation. Measurements of chicks during ringing indicated that fledging weights were markedly lower than normal. As in 2004 (the other very poor breeding season), many chicks fledged during the day rather than in the evening, but again predation rates appeared to be low and most losses at fledging were due to the failure of the chick to meet up with the male. Some male parents returned soon after they had gone to sea with the chick, suggesting that post-fledging survival may have been poor.

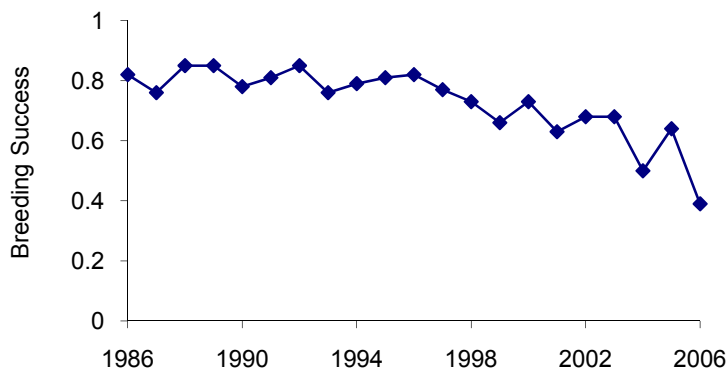


Figure 4. Breeding success (young reared per pair breeding) of common guillemot on the Isle of May 1986 – 2006

Razorbill

Breeding of razorbills was later than normal with the first egg not being laid until 5 May and the first young not seen until 10 June. Mean breeding success (0.64 and 0.62 young per pair laying for the plot average and total pairs laying; Figure 5), was close to the 1986-2005 mean (0.66, CI=0.62-0.70). No unattended razorbill chicks were recorded.

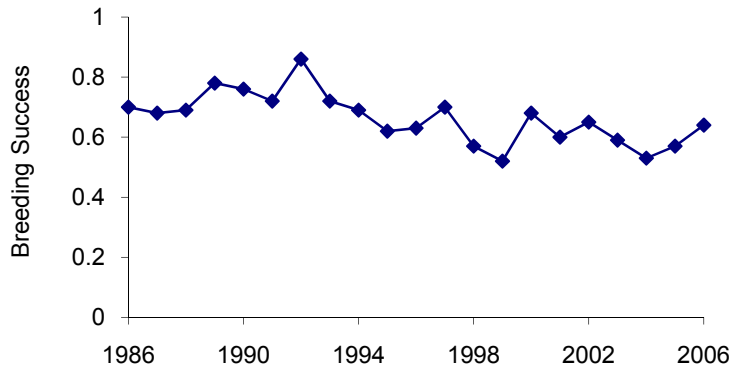


Figure 5. Breeding success (young reared per pair breeding) of razorbill on the Isle of May 1986 – 2006

Atlantic puffin

Although slightly earlier than in 2005, laying was again late, and the timing varied somewhat between areas. On 3 May, most pairs in the Kettle had laid whereas only about 50% of occupied burrows at Lady's Bed contained eggs. The first puffin carrying fish was seen on 1 June and the first young fledged on the night of 8-9 July. Back-calculation from these figures indicates that laying commenced around 19 April.

The mean breeding success based on the assumption that all chicks alive on 15-16 July fledged successfully was 0.78 chicks fledged per egg laid (Figure 6), a figure identical to the long-term mean (0.77, 95% CI=0.74-0.83). In most years very few chicks die after the young is more than about a week old, but 2006 was exceptional. Intensive studies showed that chicks grew very slowly, reached very low weights and had prolonged fledging periods. Of 38 chicks alive in the intensively studied area when the final productivity monitoring check was made, five subsequently died i.e. 0.87 rather than 1.0 survived to fledging. Assuming that the same was also true for the productivity burrows (and all the evidence suggested that this was the case), then a more accurate estimate of breeding success was 0.68 chicks fledged per egg laid i.e. 0.78×0.87 .

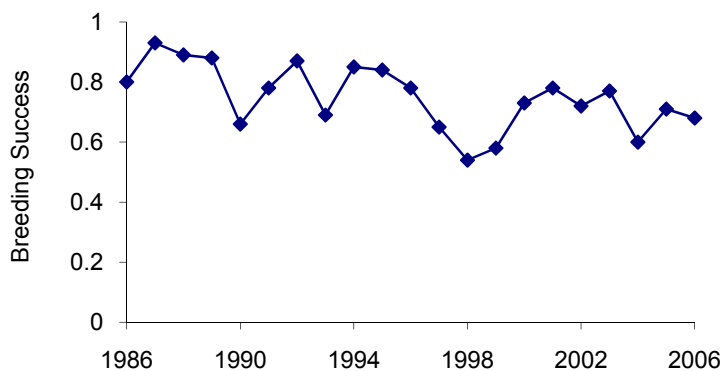


Figure 6. Breeding success (young reared per pair breeding) of Atlantic puffin on the Isle of May 1986 – 2006

3.2 Adult survival 2005-2006

Not every adult alive is seen each year and thus return rates for 2006 presented here need to be treated as minimum estimates of survival of birds seen in 2005. The results are compared with those of previous years in Table 6 in Appendix 2. All species showed an improvement on 2005 but common guillemot was still below the long-term average. During 2006 an additional 62 European shags, 10 black-legged kittiwakes, 16 Atlantic puffins and 1 common guillemot were colour-ringed. The long-term averages presented in this section do not include the current year.

European shag

After the high mortality in early 2005 the return rate for 2006 (83.3%) was back to the normal level and was slightly above the long-term average on the Isle of May (78.5%, 95% CI = 68.5-88.5) (Figure 7).

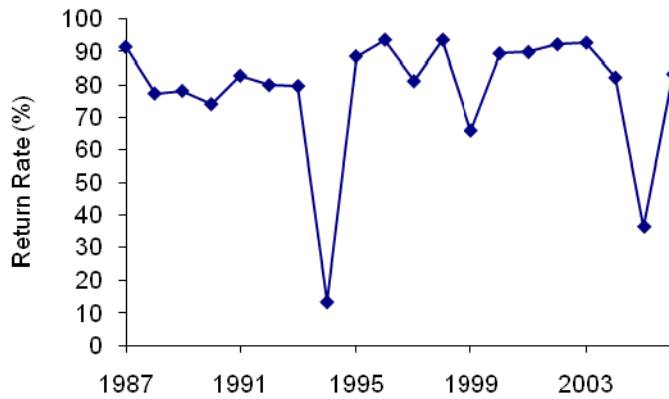


Figure 7. Annual return rates of adult European shag on the Isle of May 1987 – 2006

Black-legged kittiwake

The return rate of black-legged kittiwakes (80.9%) was markedly up on that for 2005 and slightly above the 1986-2005 average (79.3, 95% CI =75.8-82.8) (Figure 8).

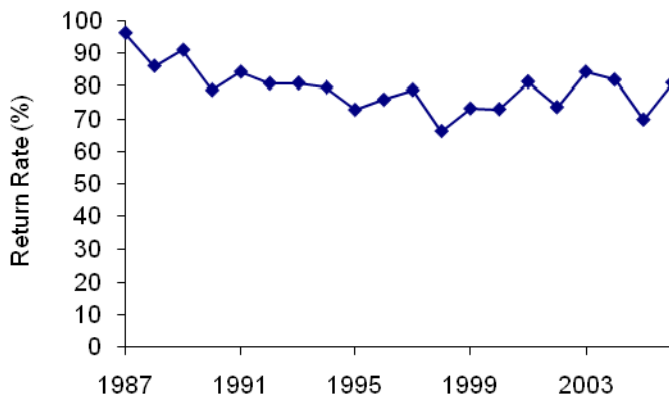


Figure 8. Annual return rates of adult black-legged kittiwake on the Isle of May 1987 – 2006

Common guillemot

The return rate of common guillemots (86.9%) was the second lowest ever recorded on the Isle of May with only that in 2005 being lower (Figure 9). As is usual on the Isle of May, observer effort was high with the study plots checked carefully every day making it highly unlikely that any birds were overlooked. The value for 2006 therefore continues the recent decline and falls well outside the 95% Confidence Interval for the 1986-2005 average (91.7, 95% CI = 90.0-93.3).

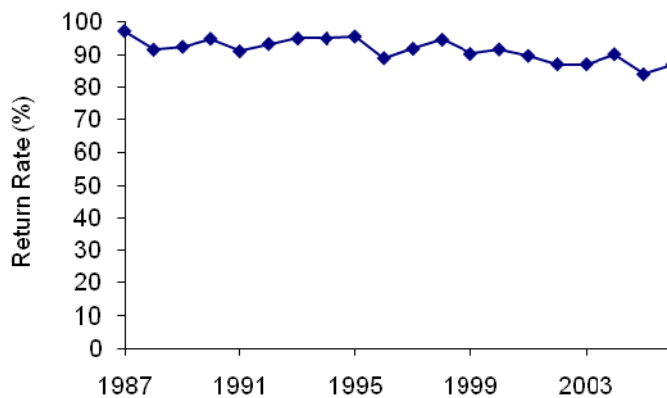


Figure 9. Annual return rates of adult common guillemot on the Isle of May 1987 – 2006

Razorbill

The return rate of razorbills (88.2%) was noticeably higher than the 1986-2005 average (81.8, 95% CI = 77.1-86.6) (Figure 10).

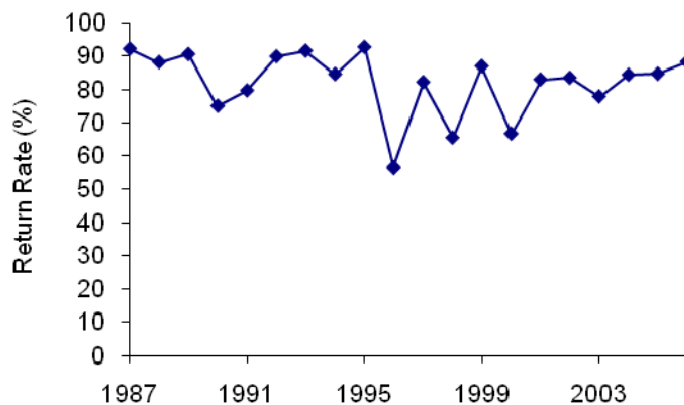


Figure 10. Annual return rates of adult razorbill on the Isle of May 1987 – 2006

Atlantic puffin

The return rate of Atlantic puffins (81.8%) was a noticeable improvement on 2005 and within the 1986-2005 average (84.0, 95% CI = 80.3-87.6) (Figure 11).

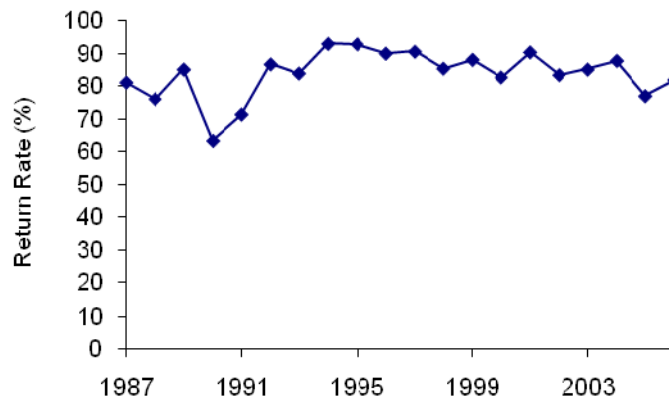


Figure 11. Annual return rates of adult Atlantic puffin on the Isle of May 1987 – 2006

3.3 Food of young

Species summaries are given in Tables 7-10, and a comparison of sandeel biomass data with recent years' results is given in Table 12 and Figure 3.

European shag

During the chick-rearing period 45 regurgitations were obtained from chicks or adults attending chicks. The most frequent prey (by occurrence in a regurgitate) were sandeels which were found in 57.7% of samples, followed by Gadidae (including whiting *Merlangius merlangus*) in 33%, and butterfish *Pholis gunnellus* in 26.6% (Figure 12). Sandeels constituted 53.4% of the biomass but, due to their small size they made up a much higher percentage (90%) of the 1101 items identified. Four regurgitates contained pipefish, presumably *Entelurus aequoreus*, with clupeid, shanny *Lipohhrys pholis*, dragonet *Callionymus lyra* and an unidentified species of crab each found in two samples.

Although the proportion of sandeels in the diet was higher than in 2004 and 2005, 2006 was still somewhat short of the quantities found prior to 2004. As with the previous two years 2006 was unusual in that the majority of sandeels obtained from shags during chick rearing were 0 group with only 12% of otoliths from older fish. Normally older (1+) sandeels make up the bulk of the diet of shags on the Isle of May.

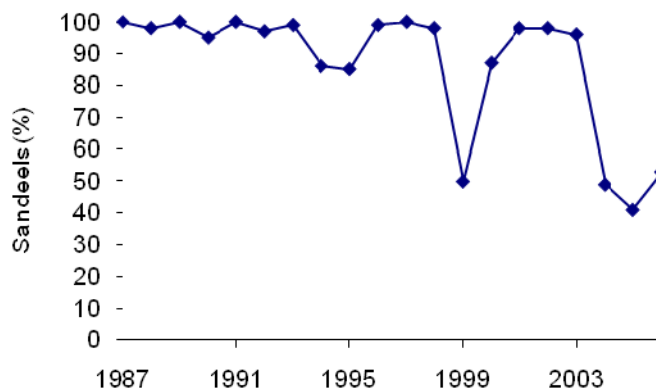


Figure 12. Percentage of sandeels (by weight) in the diet of young European shag on the Isle of May, 1987-2006

Black-legged kittiwake

Of the black-legged kittiwake food samples (n = 53) collected during the chick-rearing period, 79% contained sandeels (Figure 13). Of 3,573 otoliths examined, 95.4% were from 0 group sandeels, mostly about 5 cm long, and very few otoliths from 1+ group sandeels were found. In terms of biomass, 0 group and older sandeels contributed 62.8% and 0.6% by mass of the diet, respectively. Clupeids (mainly sprat *Sprattus sprattus*) contributed 28% of the biomass and occurred in 41.5% of regurgitations. In 2005 pipefish were found in only two samples. However, in line with casual observations, the prevalence of this species increased dramatically in 2006 with 43.4% of samples containing pipefish. In all but one sample, only traces of pipefish were found with just a few vertebrae or scales detected during lab analysis and the species rarely visible in intact regurgitations. Thus, although pipefish were being taken in significant quantities they formed very little value in terms of biomass. The remains of other items found were Gadidae (in 7 regurgitates), small crustacea (2), scampi (1), gobies Gobiidae (1) and Cottidae (1).

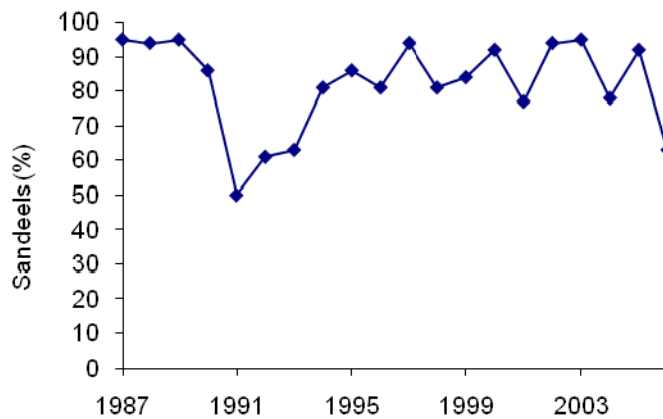


Figure 13. Percentage of sandeels (by weight) in the diet of young black-legged kittiwakes on the Isle of May, 1987-2006

Common guillemot

About 65% of the 1,475 fish delivered to chicks were clupeids. All those that could be identified to species were sprat. Most were assigned to the small (10.5 cm) or medium (11.7cm) size category (Figure 14). Small or medium sized Gadidae were the next commonest prey making up 286 (19.4%) of feeds. Identification of Gadidae in the field is extremely difficult but both saithe *Pollarchius virens* and whiting *Merlangius merlangus* were recorded. A total of 223 sandeels were recorded with most being 7-10 cm long. In biomass terms, sandeels comprised only 4% of the diet.

Unusual items brought in for display were two cuttlefish and a single squid. One very large sandeel, 16cm long, was found on the breeding ledges but nothing approaching this size was seen fed to a chick. The average weight of a prey item (estimated from body length) was 7.3 g, slightly above the 1986-2005 average of 6.2 g.

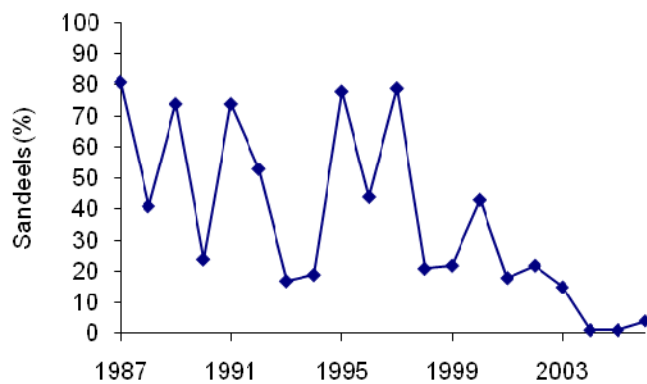


Figure 14. Percentage of sandeels (by weight) in the diet of young common guillemot on the Isle of May, 1987-2006

Razorbill

Sandeels made up the bulk of the fish brought in by razorbills, being the only species recorded in 760 (83.0%) of the 912 feeds where the fish were clearly visible (Table 9). Virtually all the sandeels were 0 group. Clupeids were present in 146 (16.0%) of loads; with most appearing to be sprats of a similar size to those brought in by puffins and guillemots i.e. 10 cm long.

Atlantic puffin

Sandeels made up 90% by number and 61% by biomass in the diet of young Atlantic puffins (Figure 15). Most sandeels were 0 group, between 4 and 7 cm long, with only 3 (0.1%) fish longer than 9 cm being recorded (Table 10). Most of the remainder of the diet was made up of small sprats and rockling. The mean load size of 7.9g was lower than in 2005 and below the long-term average (9.1 g) for puffins on the Isle of May. In contrast, the number of fish per load (14.6) was similar to the last few years but double the long term average (7.1).

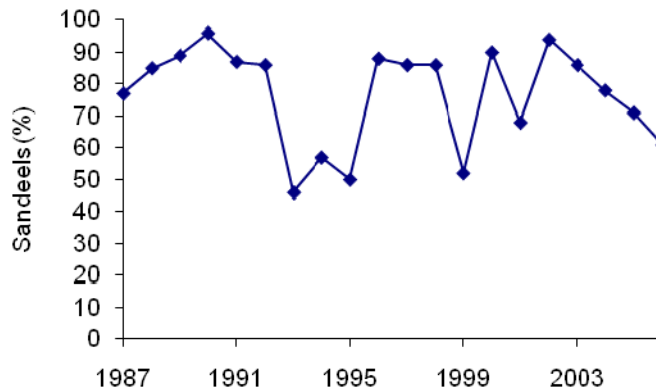


Figure 15. Percentage of sandeels (by weight) in the diet of young Atlantic puffin on the Isle of May, 1987-2006

4 Conclusions

The commercial sandeel fishery on the Wee Bankie has been closed since 2000. Seabird monitoring on the Isle of May initially indicated that breeding success, particularly of kittiwakes and shags, improved following the closure. However, in 2004 all species had a disastrous breeding season raising concerns that climate change effects in the plankton were starting to affect top predators. In line with this analyses of fish fed to young seabirds revealed that their lipid levels were extremely low indicating that feeding conditions for mid trophic fish such as sandeel and sprat were also poor in 2004 (Wanless *et al* 2005). Results from 2005 provided further evidence of deteriorating conditions with the whole of the North Sea sandeel fishery closed due to reduced catches, and some seabird breeding seasons shifting later.

In 2006 the sandeel fishery re-opened, though the area down the east coast, including the Wee Bankie remained closed. Fortunes for Isle of May seabirds were highly variable ranging from a reasonably early and successful season for shags to the worst on record for guillemots. Whilst a severe storm in June washed some guillemot eggs and chicks off sites low down on the cliffs, the main causes of failure appeared to be associated with poor feeding conditions with the problem particularly acute during the chick-rearing period. As in 2004, large numbers of chicks were left unattended and vulnerable to attack from other guillemots and razorbills. Growth of those chicks that did fledge was extremely poor and chicks fledged at all times of day rather than in the evening.

Whilst the overall figure for breeding success of kittiwakes and puffins were both close to the long-term average, there was evidence that feeding conditions deteriorated markedly towards the end of the season. Chick growth slowed down, and chicks looked weak and in poor condition. This change appeared to coincide with a marked increase in snake pipefish recorded in the diet around this time. Until a few years ago snake pipefish were rare in the North Sea but numbers have increased dramatically since 2003 (Harris 2006). Early in the 2006 season, kittiwakes were observed courtship feeding with pipefish with many found discarded around their nests. As the season progressed puffins, guillemots, shags and large gulls were all observed carrying or feeding on pipefish. Fishermen and divers also reported that the species was extremely abundant in the area. These long, thin, bony fish appear to be of limited nutritional value and birds, particularly chicks, struggle to swallow them. Towards the end of the breeding season snake pipefish were noticed scattered all over the island presumably dropped or discarded by puffins. However, the effect was most apparent in kittiwakes such that over a 10 day period from 28 July, the situation changed from just a few pipefish being seen around nests to at least 10% of chicks at any one time recorded with pipefish hanging from their bills. Nests became covered in pipefish that the chicks appeared unwilling or unable to swallow, with some nests containing over fifty fish that had been brought in in less than 24 hours.

Thus in contrast to 2005 when although conditions appeared unfavourable early in the season, the situation improved markedly from mid June onwards once 0 group sandeels became available, in 2006 conditions at the end of the season deteriorated markedly. What determines these dramatic temporal changes is currently unknown but seabird monitoring programmes such as the one on the Isle of May clearly provide a very effective way of flagging them up.

5 References

Walsh, P.M., Halley, D.J., Harris, M.P., del Nevo, A., Sim, I.M.W. & Tasker, M.L. (1995) *Seabird monitoring handbook for Britain and Ireland*. JNCC/RSPB/ITE/Seabird Group, Peterborough

Wanless, S., Harris, M.P., Redman, P. & Speakman, J. (2005) Low fish quality as a probable cause of a major seabird breeding failure in the North Sea. *Mar. Ecol. Prog. Ser.* 294: 1-8.

6 Further reading

The following is a list of papers on Isle of May seabirds published or in press since publication of the 2005 report.

Boyd, I.L., Wanless, S. & Camphuysen, C. J. (2006a) Introduction. In: Boyd I L, Wanless S, Camphuysen C J (eds) *Top predators in marine ecosystems: their role in monitoring and management*. Cambridge University Press, Cambridge, pp. 1-10.

Boyd, I.L., Wanless, S. & Camphuysen, C. J. (eds) (2006b) *Top predators in marine ecosystems: their role in monitoring and management*. Cambridge University Press, Cambridge.

Camphuysen, C. J., Scott, B. E. & Wanless, S. (2006) Distribution and foraging interactions of seabirds and marine mammals in the North Sea: multispecies foraging assemblages and habitat-specific feeding strategies. In: Boyd, I.L., Wanless, S., Camphuysen, C.J. (eds) *Top predators in marine ecosystems: their role in monitoring and management*. Cambridge University Press, Cambridge, pp. 82-97.

Crespin, L., Harris, M.P., Lebreton, J-D, Frederiksen, M. & Wanless, S. (2006a) Recruitment to a seabird population depends on environmental factors and on population size. *J. Anim. Ecol.* 75: 228-238.

Crespin, L., Harris, M.P., Lebreton, J-D & Wanless, S. (2006b) Increased adult mortality and reduced breeding success with age in a population of common guillemot *Uria aalge* using marked birds of unknown age. *J. Avian Biol.* 37: 273-282.

Daunt, F., Afanasyev, V., Silk, J.R.D. & Wanless, S. (2006a) Extrinsic and intrinsic determinants of winter foraging and breeding phenology in a temperate seabird. *Behav. Ecol. Sociobiol.* 59: 381-388.

Daunt, F., Wanless, S., Peters, G., Benvenuti, S., Sharples, J., Grémillet, D. & Scott, B. (2006b) Impacts of oceanography on the foraging dynamics of seabirds in the North Sea. In: Boyd, I.L., Wanless, S. & Camphuysen, C.J. (eds) *Top predators in marine ecosystems: their role in monitoring and management*. Cambridge University Press, Cambridge, pp. 177-190.

Enstipp, M.R., Daunt, F., Wanless, S., Humphreys, E.M., Hamer, K.C., Benvenuti, S. & Grémillet, D. (2006) Foraging energetics of North Sea birds confronted with fluctuating prey availability. In: Boyd, I.L., Wanless, S. & Camphuysen, C.J. (eds) *Top predators in marine ecosystems: their role in monitoring and management*. Cambridge University Press, Cambridge, pp. 191-210.

Frederiksen, M., Edwards, M., Richardson, A.J., Halliday, N.C. & Wanless, S. (2006) From plankton to top predators: bottom-up control of a marine food web across four trophic levels. *J. Anim. Ecol.* in press:

Frederiksen, M., Harris, M.P. & Wanless, S. (2005) Inter-population variation in demographic parameters: a neglected subject? *Oikos* 111: 209-214.

Harris, M.P. (2006) An abundance of pipefish. *British Birds* 99: 500-501.

Harris, M.P., Heubeck, M., Shaw, D.N. & Okill, J.D. (2006) Dramatic changes in the return date of Common Guillemots *Uria aalge* to colonies in Shetland, 1962-2005. *Bird Study* in press:

Harris, M.P. & Wanless, S. (2006) Laying a big egg on a little ledge: does it help a female Common Guillemot if Dad's there? *British Birds* 99: 230-235.

Humphreys, E.M., Wanless, S. & Bryant, D.M. (2006a) Elevated metabolic costs while resting on water in a surface feeder: the black-legged kittiwake. *Ibis* in press.

Humphreys, E.M., Wanless, S. & Bryant, D.M. (2006b) Stage-dependent foraging in breeding black-legged kittiwakes *Rissa tridactyla*: distinguishing behavioural responses to intrinsic and extrinsic factors. *J. Avian Biol.* 37: 436-446.

Lewis, S., Wanless, S., Elston, D.A., Schultz, M.D., Mackley, E., Du Toit, M., Underhill, J.G. & Harris, M.P. (2006) Determinants of quality in a long-lived colonial species. *J. Anim. Ecol.* in press:

Nunn, M., Barton, T.R., Wanless, S., Hails, R., Harris, M.P. & Nuttall, P. (2006a) Tick-borne Great Island Virus: (I) Identification of seabird host and evidence for co-feeding and viraemic transmission. *Parasitology* 132: 233-240.

Nunn, M., Barton, T.R., Wanless, S., Hails, R., Harris, M.P. & Nuttall, P. (2006b) Tick-borne Great Island Virus: (II) Impact of age-related acquired immunity on transmission in a natural seabird host. *Parasitology* 132: 241-253.

Reed, T.E., Wanless, S., Harris, M.P., Frederiksen, M., Kruuk, L.E.B. & Cunningham, E.J.A. (2006) Responding to environmental change: plastic responses vary little in a synchronous breeder. *Proc. R. Soc. B* in press:

Scott, B.E., Sharples, J., Wanless, S., Ross, O.N., Frederiksen, M. & Daunt, F. (2006) The use of biologically meaningful oceanographic indices to separate the effects of climate and fisheries on seabird breeding success. In: Boyd, I.L., Wanless, S. & Camphuysen, C.J. (eds) *Top predators in marine ecosystems: their role in monitoring and management*. Cambridge University Press, Cambridge, pp. 46-62.

Sims, M., Wanless, S., Harris, M.P., Mitchell, P.I. & Elston, D.A. (2006) Evaluating the power of monitoring plot designs for detecting long-term trends in the numbers of common guillemots. *J. Appl. Ecol.* 43: 537-546.

Wanless S, Frederiksen M, Daunt F, Scott B E, Harris M P (2006) Black-legged kittiwakes as indicators of environmental change in the North Sea: evidence from long-term studies. *Prog. Oceanogr.* in press:

Watanuki Y, Takahashi A, Daunt F, Sato K, Miyazaki M, Wanless S (2006a) Underwater images from bird-borne cameras provide clues to poor breeding success of European shags

in 2005. *British Birds* in press:

Watanuki Y, Wanless S, Harris M, Lovvorn J R, Miyazaki M, Tanaka H, Sato K (2006b)
Swim speeds and stroke patterns in wing-propelled divers: a comparison among alcids and
a penguin. *J. Exp. Biol.* 209: 1217-1230.

7 Appendices

Appendix 1: Breeding success

Table 1. Breeding success of northern fulmars on the Isle of May in 2006

<i>Area</i>	<i>Incubating birds</i>	<i>No. probably hatched</i>	<i>Young fledged</i>
Cleaver	11	10	4
Pilgrim's Haven	3	3	1
Cornerstone	2	2	1
Loch (S)	30	18	13
Greengates	55	36	19
Horse Hole	9	7	5
Tarbet	18	16	13
Low Light	7	3	3
Colm's Hole	3	2	2
Rona	1	0	0
Total	139	97	61
Overall mean			0.44 fledged/ pair

Notes:

Incubating birds were those sitting tight on three checks or where an egg was seen. Chicks present on 21 August were assumed to have fledged.

Table 2. Breeding success of European shags on the Isle of May in 2006

	<i>Total incubated</i>	<i>Other nests</i>	<i>Young fledged</i>			<i>Total</i>	<i>Fledging success per completed nest</i>
			<i>1</i>	<i>2</i>	<i>3</i>		
Maidens	5	0	1	4	0	9	1.80
South Horn	6	0	1	4	0	9	1.50
Pilgrim's Haven	1	0	0	1	0	2	2.00
Mill Door (N)	6	0	2	2	0	6	1.00
Mill Door (S)	5	1	0	4	0	8	1.60
Horse Hole	18	0	4	6	2	22	1.22
North Horn	24	3	6	7	1	23	0.96
Tarbet	8	2	3	1	2	11	1.38
Low Light	7	0	3	2	0	7	1.00
Colm's Hole	1	0	0	1	0	2	2.00
Mean ± se							1.45±0.13
Total	81	6	20	32	5	99	1.22

Notes:

No nests were built in the plots at South Ness, Lady's Bed Stack, South Horn, Chatterstones, North of Pilgrim's Haven, or Bishop's Cove in 2006. Two large young present on 21 August were assumed to have fledged.

Table 3. Breeding success of black-legged kittiwakes on the Isle of May in 2006

<i>Area</i>	<i>Completed nests</i>	<i>Trace nests</i>	<i>Other pairs with site</i>	<i>Fledged young per completed nest</i>				<i>Total young produced</i>	<i>Fledging success per completed nest</i>
				0	1	2	3		
Cleaver	21	5	5	19	2	0	0	2	0.10
South Horn	57	3	7	28	21	8	0	37	0.65
Pilgrim's Haven	26	1	0	9	15	2	0	19	0.73
South Face	16	1	8	6	9	1	0	11	0.69
Colony 4	46	9	3	22	20	4	0	28	0.61
Hide Face	32	1	5	20	11	1	0	13	0.41
Cornerstone	84	3	6	44	37	3	0	43	0.51
Lock (S)	5	0	7	5	0	0	0	0	0.00
Loch (N)	63	2	10	62	1	0	0	1	0.02
Greengates	58	4	1	36	20	2	0	24	0.41
Bishop's Cove	37	3	3	18	17	2	0	21	0.57
Iron Bridge	11	0	0	5	6	0	0	6	0.55
Rona	40	1	2	18	18	4	0	26	0.65
Tarbet	44	4	0	10	26	8	0	42	0.95
Low Light	47	5	10	45	1	1	0	3	0.06
Colm's Hole	10	0	1	6	3	1	0	5	0.50
Mean ± se									0.46± 0.05
Total	613	45	70	360	215	38	0	291	0.47

Table 4. Breeding success of auks on the Isle of May in 2006

<i>Species</i>	<i>Area</i>	<i>Pairs laying</i>	<i>Young hatched</i>	<i>Young "fledged"</i>	<i>Young leaving / pair</i>
Guillemot	Dense	291	251	103	0.35
	Hide / White Ledge	94	81	34	0.36
	Colony 4	260	208	102	0.39
	South	50	40	15	0.30
	Cornerstone	237	207	128	0.54
	Mean ± se				
	Total	932	787	382	0.41
Razorbill	Hide / White Ledge	31	21	16	0.52
	Colony 4	63	44	36	0.57
	South	22	16	18	0.82
	Cornerstone	74	65	48	0.65
	Mean ± se				
	Total	190	149	118	0.62
Puffin	Lady's Bed	43		27	0.63
	Kirkhaven	39		32	0.82
	Burrian	39		31	0.79
	Rona	45		39	0.87
	Mean ± se				
	Total	166		129	0.78

Notes:

The estimates for guillemot and puffin are maxima (see text).

Some guillemots scored as fledged could well have died or failed at fledging.

For the puffin, the number of young that hatched was unknown. Based on the results of regular checks of nearby burrows, 5 out of 38 chicks alive when the final productivity check was made subsequently died; the true success was probably about 0.68.

Table 5. Breeding success (mean number of young reared per breeding pair) of seabirds on the Isle of May, 1993-2006

<i>Species</i>	1993	1994	1995	1996	1997	1998	1999
Northern fulmar	0.44 (121)	0.47 (122)	0.48 (126)	0.44 (135)	0.37 (136)	0.35 (120)	0.47 (115)
European shag	0.21 (80)	0.68 (74)	0.84 (131)	1.05 (105)	0.92 (109)	0.85 (125)	0.33 (58)
Black-legged kittiwake	0.07 (1034)	0.16 (861)	0.40 (874)	0.56 (825)	0.40 (822)	0.02 (683)	0.20 (616)
Common guillemot	0.76 (797)	0.79 (775)	0.81 (805)	0.82 (786)	0.77 (842)	0.73 (852)	0.66 (870)
Razorbill	0.72 (119)	0.69 (134)	0.62 (143)	0.63 (140)	0.71 (132)	0.57 (134)	0.52 (142)
Atlantic puffin	0.69 (182)	0.85 (189)	0.84 (180)	0.78 (173)	0.65 (166)	0.54 (179)	0.58 (181)
	2000	2001	2002	2003	2004	2005	2006
Northern fulmar	0.37 (143)	0.26 (134)	0.48 (131)	0.44 (109)	0.21 (97)	0.27 (135)	0.44 (139)
European shag	1.48 (127)	1.53 (135)	1.66 (130)	1.83 (156)	0.25 (103)	0.48 (42)	1.22 (81)
Black-legged kittiwake	0.97 (545)	0.61 (459)	0.47 (477)	0.77 (423)	0.29 (476)	0.85 (675)	0.47 (613)
Common guillemot	0.73 (942)	0.63 (975)	0.68 (955)	0.68 (1014)	0.50 (984)	0.63 (945)	0.41 (932)
Razorbill	0.68 (149)	0.60 (167)	0.65 (167)	0.59 (177)	0.54 (190)	0.55 (200)	0.62 (190)
Atlantic puffin	0.73 (132)	0.78 (185)	0.72 (174)	0.77 (195)	0.60 (196)	0.71 (184)	0.68 (166)

Notes:

The number of pairs followed is given in brackets. Details of the monitoring methods for these species can be found in this and previous reports to JNCC.

Appendix 2: Annual return rates

Table 6. Annual return rates of adult seabirds on the Isle of May, 1990-2006

<i>Species</i>	<i>No. seen in 2005</i>	<i>No. seen in 2006</i>	<i>Return rate (%)</i>						
			<i>2005-06</i>	<i>2004-05</i>	<i>2003-04</i>	<i>2002-03</i>	<i>2001-02</i>	<i>2000-01</i>	<i>1999-00</i>
Kittiwake	152	123	80.9	69.7	81.8	84.2	73.5	81.2	72.9
Guillemot	337	293	86.9	83.9	90.1	87.0	87.0	89.6	91.6
Razorbill	51	45	88.2	84.6	84.3	77.8	83.8	82.9	66.7
Puffin	203	166	81.8	77.0	87.9	85.2	83.5	90.5	82.8
Shag	108	90	83.3	36.4	82.2	92.7	92.2	89.8	89.4
	<i>1998-99</i>	<i>1997-98</i>	<i>1996-97</i>	<i>1995-96</i>	<i>1994-95</i>	<i>1993-94</i>	<i>1992-93</i>	<i>1991-92</i>	<i>1989-90</i>
Kittiwake	73.1	66.2	78.7	75.8	72.7	79.5	80.8	80.7	78.7
Guillemot	90.2	94.6	91.8	88.9	95.6	95.0	95.0	93.3	94.9
Razorbill	86.9	65.5	82.1	56.6	92.6	84.5	91.5	89.8	75.0
Puffin	88.2	85.5	90.7	90.1	93.0	93.1	84.0	86.8	63.3
Shag	65.8	93.6	91.1	93.6	88.5	13.4	79.6	79.9	74.0

Notes:

Only birds which had definitely bred in 2005 or earlier are included.

Directly comparable figures for earlier seasons are given. These have not been corrected for missing birds seen in later years, and for some species may severely under-estimate actual survival rates.

These figures should not be used for population dynamics calculations without consultation with S Wanless.

Appendix 3: Chick diet

Table 7. Food of young black-legged kittiwakes and European shags on the Isle of May during chick-rearing in 2006

	<i>Black-legged kittiwake</i>	<i>European shag</i>
No. of regurgitations	53	45
Range of dates	23 June-30 July	23 May-13 July
Total weight (g)	1001	1628
% regurgitations with sandeels	79	57.7
with Gadidae	13	33
with Clupeidae	41.5	0.04
with flatfish	0	0
with butterfish	0	26.6
with Cottidae	0.02	0
with pipefish	43.4	8.3
% (by weight) of sandeels in sample	63.5	53
	95.6	82.0
% (by number) of sandeels in sample		
Lengths of most sandeels (cm)	5	7.6
Other remains identified	Small crustacea (2 samples), Gobiidae (1), scampi (1)	Dragonet <i>Callionymus lyra</i> (2), small crab (2), shanny (<i>Lipohrhys pholis</i>)(2)

Notes:

Samples were collected from chicks or adults during the chick-rearing period.

Counts and lengths of fish were based on otoliths retrieved from the regurgitations.

Table 8. Food of young common guillemots on the Isle of May in 2006

	<i>No. of sandeels</i>				<i>No. of Clupeidae</i>				<i>No. of Gadidae</i>		
	<i>minute</i>	<i>small</i>	<i>medium</i>	<i>large</i>	<i>minute</i>	<i>small</i>	<i>medium</i>	<i>large</i>	<i>minute</i>	<i>small</i>	<i>medium</i>
Length (cm)	5	7	10	13	7	10.5	11.7	12.5	7	8.5	12
All-day watches											
24 June	0	3	6	0	0	9	20	0	17	4	1
25 June	0	22	16	0	1	57	32	2	12	1	1
30 June	0	5	3	0	1	18	12	0	10	4	1
3 July	1	0	1	1	0	37	16	1	1	3	0
Other records											
8 June - 17 July	6	80	78	1	0	325	403	19	169	65	9
Total	7	110	104	2	2	446	483	22	209	77	12

Notes:

In addition, one fish was seen which was neither sandeel, clupeid nor gadid.

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

Table 9. Food of young razorbills on the Isle of May in 2006

	<i>Sandeels</i>			<i>Single Clupeidae</i>			<i>Several Clupeidae</i>		
	<i>small</i>	<i>medium</i>	<i>large</i>	<i>small</i>	<i>medium</i>	<i>large</i>	<i>Small</i>	<i>medium</i>	<i>large</i>
All-day watches									
24 June	82	5				1	1		1
25 June	29	2	11	1	1		1		1
30 June	23	5	4		2	7	4		3
06 July	3	1			4		7		2
Other records									
16 June –16 July	531	50	14	1	48	32	10		19
Total	668	63	29	2	55	40	23	26	0

Notes:

All the small sandeels appeared to be 0 group.

10 loads of dominant clupeids contained some sandeels, mostly 0 group.

9 loads of dominant sandeels contained some clupeids mostly 0 group.

6 loads of purely multiple sandeels contained assorted size fish.

3 loads of purely multiple clupeids contained assorted size fish.

2 loads contained equal small clupeids and small sandeels.

5 Gadidae and 1 butterfish were also recorded.

Sizes are qualitative as it was not possible to collect food samples from razorbills.

Most data were collected by Chris Thaxter and David Campbell.

Table 10. Food of young Atlantic puffins on the Isle of May, June to August 2006

	<i>Sample size</i>	<i>Mean</i>	<i>s.e</i>
a) Load weight (g)	172	7.9	0.34
b) Fish/load	173	14.6	0.74
c) Numbers and lengths of fish (mm)			
Sandeels <i>Ammodytes sp.</i>	2057	53.3	0.20
Unidentified Clupeid (<i>Clupeidae</i>)	15	48.1	5.02
Sprat <i>Sprattus sprattus</i>	57	107.0	1.07
Cod <i>Gadus morhua</i>	14	49.5	4.17
Saithe <i>Pollachius virens</i>	11	44.6	2.28
Goby (<i>Gobiidae</i>)	4	35.3	1.70
Rockling <i>sp.</i> (<i>Gadidae</i>)	7	39.6	1.84
Whiting (<i>Merlangius merlangus</i>)	97	30.7	0.38

Note:

Most of the Clupeidae category were probably small sprat, most of the Gadidae were probably whiting. The gobies were probably crystal gobies *Crystallogobius linearis*.

Table 11. Percentage of black-legged kittiwake broods of one and two chicks that had no adults present during daily checks in the middle of the day on the Isle of May, 1986-2006

<i>Year</i>	<i>One young</i>	<i>Two young</i>
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
1999	5	25
2000	2	8
2001	6	19
2002	6	19
2003	0.2	7
2004	31	48
2005	4.5	21
2006	19.5	38.7

Notes:

Figures are based on 87-250 broods, in the same areas each year and are the means of daily checks made from the date that the first neglected chick was noted, to the start of fledging in the areas. (Details of methods are given in Wanless & Harris, *Scottish Birds* 15 (1989): 156-161.) In 2006 observations were made on 160-250 broods between 11 and 31 July.

Table 12. Percentage of sandeels (by weight) in the diet of young seabirds on the Isle of May, 1988-2006

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

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Shag	100	98	<50	87	95	98	96	49	41	53
Kittiwake	94	81	84	92	76	94	91	79	92	63
Guillemot	79	21	22	43	18 22		15	2	1	4
Puffin	86	86	52	90	68	94	86	78	71	61

Notes:

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

Sandeels also made up the bulk of the food of young razorbills in all years except 2004, but it is extremely difficult to assess proportions in terms of biomass.

Table 13. Black-legged kittiwake first-egg dates and clutch-sizes on the Isle of May, 1986-2006

<i>Year</i>	<i>First date egg seen</i>	<i>Mean clutch-size (eggs)</i>
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
1999	16 May	1.99
2000	5 May	1.89
2001	17 May	1.93
2002	10 May	1.87
2003	9 May	1.49
2004	22 May	1.65
2005	30 May	1.73
2006	27 May	1.54