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Isle of May seabird studies in 2008

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Summary

The 2008 season on the Isle of May was mixed. Of the six species studied intensively, European shag had its highest productivity on record whereas northern fulmar had its worst ever season. Atlantic puffin showed a marginal improvement on the lowest productivity experienced in 2007. Common guillemot productivity was well up on the previous year but, as with razorbill, was still below average, while black-legged kittiwakes had the worst season for ten years. Weather conditions were not exceptional so difficult feeding conditions were thought likely to be the main reason for such low productivity in most species. Return rates, although well below average, were slightly up for black-legged kittiwake, Atlantic puffin and European shag, while for common guillemot it was the lowest on record. 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. Comparatively few 1+ group sandeels were present in food samples during the chick-rearing period. Far fewer snake pipefish were noted in the seabird diet than in the previous three years.

- Northern fulmar breeding success (0.20 chicks per incubating pair) was the worst on record. Furthermore, this figure is an overestimate since a white-tailed eagle was observed predated on fulmar chicks late in the season, including one confirmed to be from a monitoring plot. The full impact of this eagle on fulmar breeding success is not known.
- European shags began breeding earlier than in 2007 and had the most successful season on record. Shag was the only study species for which productivity (1.9 chicks per pair) was above the long term mean. Following high mortality during the winter of 2006/07, return rate increased to 70.6% but was still below the long-term mean. As in the previous two years, the food was unusually varied with sandeels making up 48% by mass of the diet. Of sandeel otoliths, 40% were from older (1 group or older) fish whereas in 2007 all had been from this age class.
- Black-legged kittiwakes had a very poor season with productivity (0.23 chicks per incubated nest) the lowest since 1999 and well below the long term average. Adult return rate (66.4%) was poor with only two other years showing lower values. The proportion of sandeel in the diet (59% by biomass) was the third lowest recorded, with high proportions of clupeid (20%) and rockling (12%) recorded.
- Although better than in 2007, breeding success of common guillemots (0.63 chicks per pair laying) continued a worrying long-term decline. As in the previous three years, many chicks were left unattended but, surprisingly, few were taken by gulls. Return rate of adults (75.0%) was the lowest on record. Adults fed their chicks mainly on sprats (76%) with sandeels (20%) the main alternative.
- Razorbill breeding success (0.58 chicks leaving per pair) was well below the long-term average, due mainly to unusually poor chick survival. Adult return rate (69.4%) was well down on the long-term average. Chicks were fed mainly 0 group sandeels.
- The breeding success of Atlantic puffins at 0.48 fledged per pair laying was the second lowest on record. Return rate for adults (59.4%) was also the second lowest on record. This was the second year in a row of poor adult return rate, following the lowest ever in 2007. Chicks were mainly fed 0 group sandeels (63% by number, 73% by biomass).

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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. The breeding success of kittiwakes and shags, which had declined whilst the fishery was in operation, increased during the period 2000-2003, suggesting that the industrial fishery on the Wee Bankie had adversely affected this species.

However, since 2004 breeding success and adult return rate has been substantially lower for several species, including kittiwakes, despite the fishing ban still being in operation. The common guillemot has been particularly hard hit, with the period 2004-2008 representing the five worst breeding seasons on record. Particularly poor breeding seasons were recorded in several species in 2004 and 2007. In recent years there have

also been changes in seabird diet with the sudden appearance of snake pipefish *Entelurus aequoreus* the most dramatic. Although numerous this prey is difficult to digest and of poor nutritional value (Harris *et al* 2007).

Continued monitoring of the Isle of May seabirds is vital to assess their performance, and in particular to determine whether the current run of poor seasons is a temporary setback in the recovery recorded in some species since the fishery closure, or the start of a sustained period during which poor environmental conditions override any benefit of fishery closure, and catastrophic years such as 2004 and 2007 become commonplace.

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 4, 7 and 10 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 and 28 July to determine those that had hatched eggs. A final check was made on 19 August, when chicks present were assumed to have fledged successfully.

European shag

The positions of nests constructed in nine areas were marked on photographs and the state and contents of these nests were checked weekly from 16 April until 1 August. Young (medium-sized or larger) that remained on 1 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 2008. Checks of nests were made on 4 and 11 June when regular checks of sample areas showed that most pairs had constructed nests. The first fledged young was seen on 17 July and a complete check of nests was made on 18 July. Further checks of nests with small chicks on 18 July were made on 24 and 30 July. Chicks alive on 30 July 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 5-9 May (by when most pairs had laid). The staked burrows were re-checked on 15-16 July at the start of 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 Taret, 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 2008, otherwise from previously published relationships. Observations were made of fish brought to young common guillemots and razorbills during three 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 gives 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 19 May. Breeding success at 0.20 chicks fledged per incubating pair (Figure 1) was the lowest since monitoring began. This compared to the long term average of 0.39 (CI=0.35-0.44). However, after the final check a white-tailed eagle from the Tay reintroduction scheme was observed predated on fulmar chicks by SNH staff and Scottish Seabird Centre cameras. Their observations confirmed that this bird took one chick from the Pilgrims Haven plot, but it is not known whether other fulmar chicks from elsewhere on the island were also taken. The methodology used is not designed to determine when breeding attempts fail, but losses appeared to have been considerably higher during incubation than during chick-rearing.

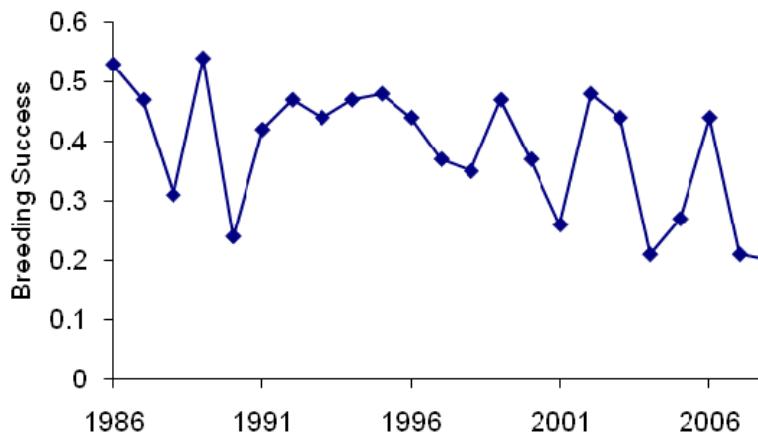


Figure 1. Breeding success (young reared per pair breeding) of Northern fulmar on the Isle of May 1986 – 2008

European shag

In 2008, 60 pairs bred in the study plots, compared to 57 in 2007. Breeding was early with the first egg laid on 9 April; this compared with 25 and 20 April in 2006 and 2007 and earlier than the 1986-2007 average of 12 April. Of the 60 nests built, all pairs laid and raised a total of 114 chicks to fledging. Productivity at 1.9 chicks per nest built was the highest on record (Figure 2). The 1986-2007 average was 0.92 (CI=0.73-1.11).

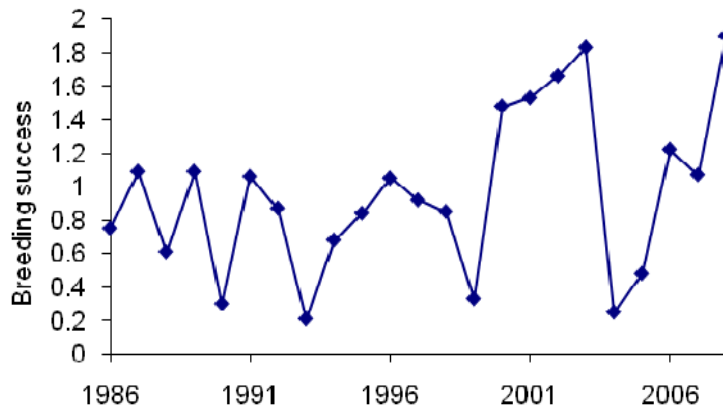


Figure 2. Breeding success (young reared per pair breeding) of European shag on the Isle of May 1986 – 2008

Black-legged kittiwake

Breeding of black-legged kittiwakes in 2008 was earlier than in the previous few seasons although still slightly later than the long term mean. The first courtship feed was observed on 2 May (nearly a week later than 2007) but the first egg was found on 15 May (four days earlier). The first chick was recorded on 11 June and the first fledgling on 17 July. The mean clutch size, including complete nests where no eggs were laid, was 1.75 eggs, slightly down on 2007 (1.8) but still higher than previous years (Table 13). Five clutches of three eggs were recorded among the 394 nests checked for clutch-size which, although considerably down on the 21 in 2007, was better than the single three-egg clutches recorded in each of the previous two years.

The total number of pairs breeding in the study plots (485) was well down on the previous three years. Mean breeding success was 0.18 (\pm se 0.04) chicks per completed nest, averaged across the plots, 0.23 after pooling areas (Figure 3). This value was well below the 95% Confidence Interval for the 1986-2007 average (0.54, CI=0.39-0.69) and the lowest since 1999. Breeding success was very variable between plots which may have been down to high predation levels in some areas. Although predation by gulls, particularly herring gulls, has been suspected in past years it was very noticeable in 2008 with actual observations on several occasions at different locations in particular North Lochside.

The first broods without an adult present were noted on 9 July. The frequency of neglected broods of one chick increased from 14% up to 81% by the time of the first fledging while that of broods of two increased steadily from 25% to 100%. The average daily rates of unattended chicks in broods of one and two chicks were 46.7% and 72.4%, respectively. Only three broods of two fledged in the plots and no brood of three young fledged on the island.

The 2008 season for kittiwakes began positively with early signs of nesting activity, feeding flocks around the island and a return towards normal laying times. Although the number of kittiwake nests in the plots was considerably down in 2008 the clutch sizes were reasonably high. But just as in 2007, there was a gradual decline in the numbers of active nests. Some clutches were abandoned late in incubation, later increasing numbers of broods did not have an adult in attendance and at least one chick from virtually all broods of two died.

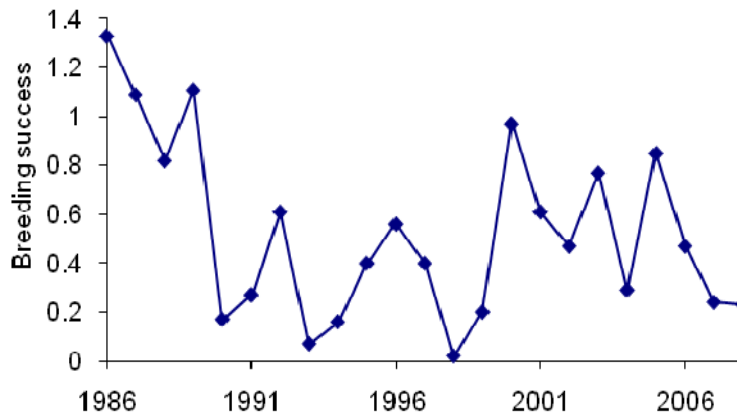


Figure 3. Breeding success (young reared per pair breeding) of black-legged kittiwake on the Isle of May 1986 – 2008

Common guillemot

Breeding numbers were again lower with a total of 807 pairs laying in the study plots compared with 932 in 2006 and 850 in 2007. Although a further 58 sites were occupied but not bred at, this was lower than the 100 such sites in 2007. There can be no doubt that the breeding population is now declining.

The first guillemot eggs (3) were seen on 30 April, slightly later than in 2007 (25 April) but in line with most recent years. The first young left on the night of 22-23 June but the first serious fledge was not until 30 June/1 July. Breeding success (0.59 and 0.63 young per pair laying for the plot average and summed total, respectively; Figure 4) was a welcome improvement over 2007 (0.26 and 0.28, respectively) but still continued a gradual long-term decline. Although the total hatching success (81%) was close to the long-term average (84%), chick success (78%) was well below the norm of 89%.

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 and 2007 and again in 2008. Although some chicks were lost to herring and great black-backed gulls, most neglected chicks survived even when gulls came on to the ledges to pick up deserted/addled eggs and fish that had been dropped. Females spent little time at the breeding-sites once their mates had taken the chick to sea and the colonies emptied of birds several weeks earlier than the case even a few years ago.

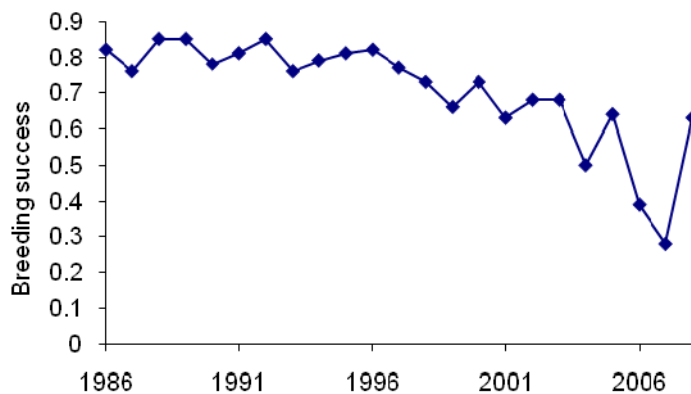


Figure 4. Breeding success (young reared per pair breeding) of common guillemot on the Isle of May 1986 – 2008

Razorbill

Breeding numbers of razorbills in the study plot have gradually declined from 200 pairs laying in 2005 to 170 in 2008. The first egg was seen on 26 April – two days earlier than the first guillemot egg. Mean breeding success (0.59 and 0.58 young per pair laying for the plot average and total pairs laying; Figure 5), was lower than the 1986-2007 mean (0.66, CI=0.63-0.70), due to the poor survival of chicks (0.74 that compared with a mean for the previous 26 seasons of 0.90, CI=0.86-0.93). No unattended chicks were seen and this poor success was, at least in part, due to an unusual amount of predation by herring and great black-backed gulls.

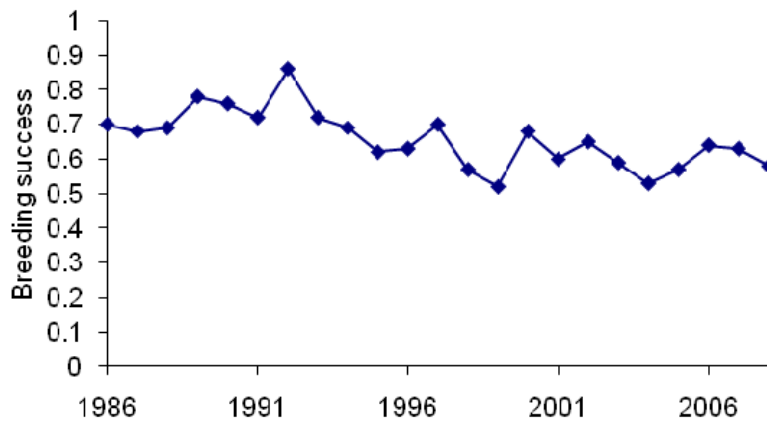


Figure 5. Breeding success (young reared per pair breeding) of razorbill on the Isle of May 1986 – 2008

Atlantic puffin

A count of occupied burrows of about half the colony during the end of April indicated that numbers of puffins breeding on the Isle of May had declined by ca. 30% since the last survey in 2003. Many burrows that were known to have been bred in in 2007 had not been visited (as shown by mats of dried vegetation blocking the entrances). Birds appeared to return to the colonies late and to spend little time on land prior to laying.

The first puffin carrying fish was seen on 31 May and the first fledged young was seen on the sea on 8 July with the first leaving the study burrows the next night. Back-calculation from these figures indicates that laying commenced around 19 April. Checks of burrows during the census confirmed late breeding with the first laying dates now being over a week later than 7-10 years ago.

The mean breeding success was based on the assumption, backed up by regular checks of burrows to weigh chicks, that all chicks alive on 15-16 July fledged successfully. The mean breeding success of 0.48 chicks per egg laid (Figure 6), although much higher than in 2007 (0.29) was still the second lowest recorded and well below the 1977-2007 mean (0.76, 95% CI=0.71-0.81). The reason for success being so low at Burrian was unknown.

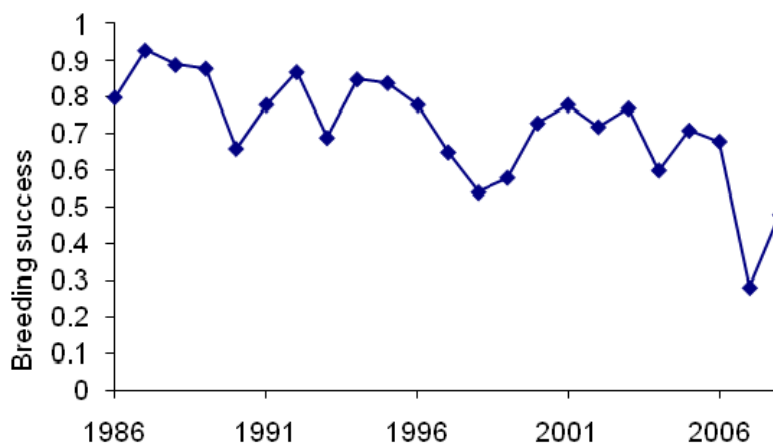


Figure 6. Breeding success (young reared per pair breeding) of Atlantic puffin on the Isle of May 1986 – 2008

3.2 Adult survival 2007-2008

Not every adult alive is seen each year and thus return rates for 2008 presented here need to be treated as minimum estimates of survival of birds seen in 2007. The results are compared with those of previous years in Appendix 2. During 2008 an additional 29 European shags, 25 black-legged kittiwakes, 35 Atlantic puffins, 12 razorbills and 6 common guillemot were colour-ringed. The long-term averages presented in this section do not include the current year.

European shag

The return rate for 2008 (70.6%) was an improvement on 2007 (60.8%) but still below the long-term average (77.9%, 95% CI = 69.3-86.5) with only 1994, 1999, 2005 and 2007 having lower values (Figure 7).

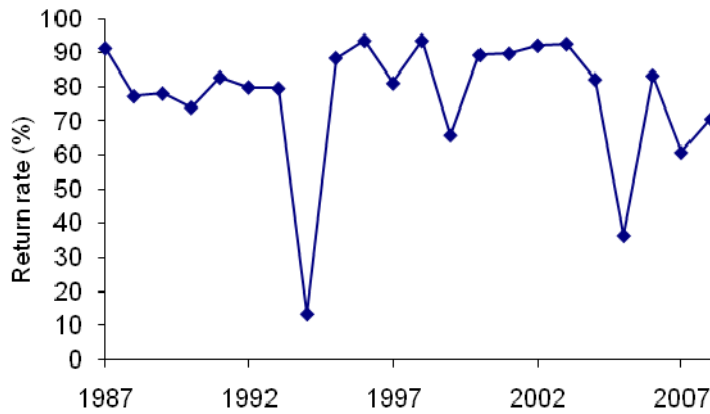


Figure 7. Annual return rates of adult European shag on the Isle of May 1987 – 2008

Black-legged kittiwake

The return rate of black-legged kittiwakes (66.4%) was a slight improvement on 2007 (62.9%) it was still one of the lowest recorded and substantially below the 1986-2007 average (78.6, 95% CI =75.3-81.9) (Figure 8).

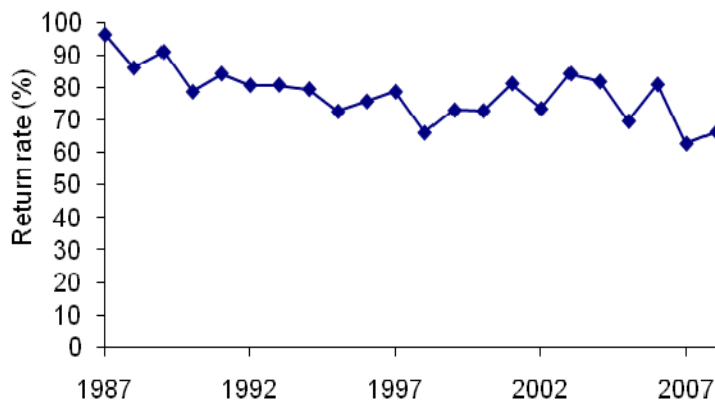


Figure 8. Annual return rates of adult black-legged kittiwake on the Isle of May 1987 – 2008

Common guillemot

Although the return rate of common guillemots (75.0%) was only slightly lower than in 2007 (75.2%), it is the lowest recorded on the Isle of May. As is usual, observer effort was high with the study plots checked carefully every day making it highly unlikely that any birds were overlooked. The values for 2007 and 2008 therefore continues the recent decline and fall well outside the 95% Confidence Interval for the 1986-2006 average (91.4, 95% CI = 89.9-92.9) (Figure 9). This species is usually very consistent in terms of the percentage of colour-ringed birds alive one year that return the next year, so the recent large drop in return rate is very worrying.

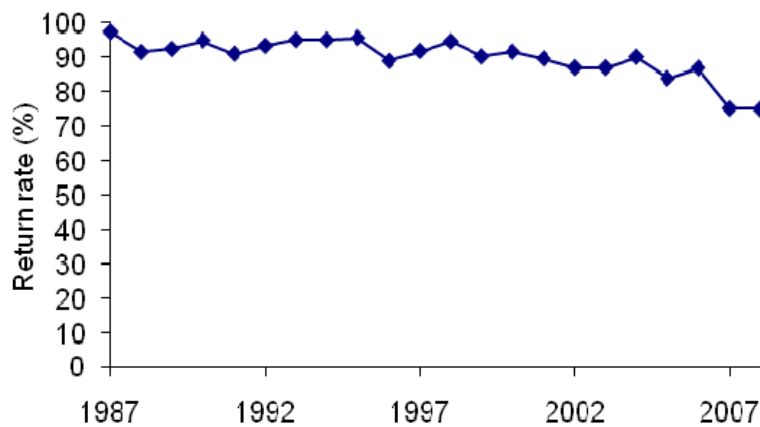


Figure 9. Annual return rates of adult common guillemot on the Isle of May 1987 – 2008

Razorbill

The return rate of razorbills (69.4%) was well below the 1986-2007 average (82.1, 95% CI = 77.9-86.3) (Figure 10).

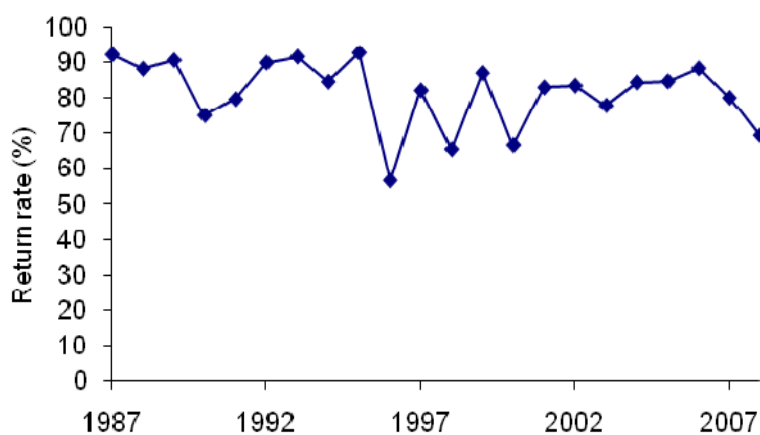


Figure 10. Annual return rates of adult razorbill on the Isle of May 1987 – 2008

Atlantic puffin

In 2008, the return rate of Atlantic puffins was 59.4%. The return rate in 2007 had been 56.9%. These two estimates were by far the lowest on record and well below the 1986-2006 average (83.9, 95% CI = 80.6-87.2) and suggest a dramatic reduction in adult survival, probably explaining at least in part the much reduced population estimate in 2008 compared to 2003 (Figure 11).

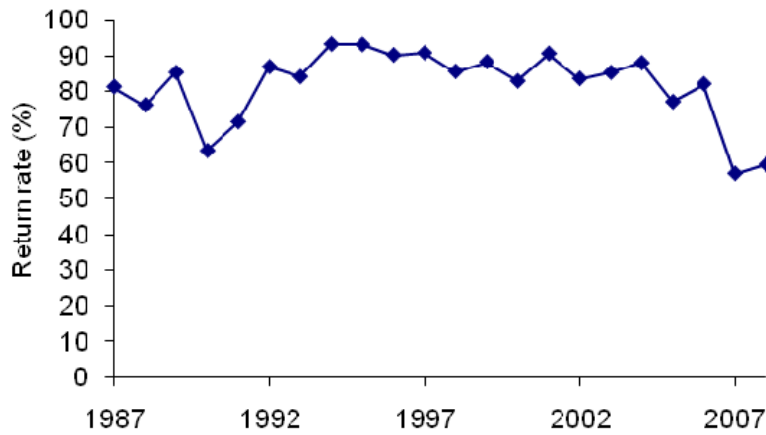


Figure 11. Annual return rates of adult Atlantic puffin on the Isle of May 1987 – 2008

3.3 Food of young

Appendix 3 gives species summaries in Tables 7-10, and a comparison of sandeel biomass data with recent years' results in Table 12.

European shag

The most frequent prey (by occurrence in a regurgitate), in the 36 regurgitations was sandeel *Ammodytes marinus* which occurred in 61.1% of samples (Figure 12), followed by Gadidae (including whiting *Merlangius merlangus* and rockling) in 44.4%, Gobiidae 33.3% and butterfish *Pholis gunnellus* in 25% (Table 7). Sandeels constituted 48.4% of the biomass, a large increase on 28% in 2007. The remains of other items found were Clupeidae (probably sprat *Sprattus sprattus*, in 6 regurgitates), crustacea (6), bull-rout *Myoxocephalus scorpius* (4), mollusc (3), dragonet *Callionymus lyra* (2), and small flatfish (possibly long rough dab *Hippoglossoides platessoides*, 2). Unlike the previous two years no pipefish were found. In the years 2004 to 2006 an unusually high proportion of 0 group sandeels occurred in the diet during chick-rearing but in 2007 all sandeels were older (1+). In 2008, 0 group again dominated comprising 60% of sandeel otoliths in the obtained regurgitates.

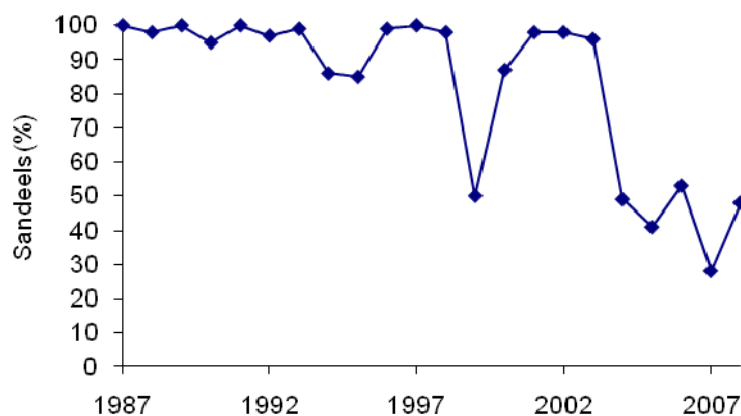


Figure 12. Percentage of sandeels (by weight) in the diet of young European shag on the Isle of May, 1987-2008

Black-legged kittiwake

Of the 46 food samples, 76.1% contained sandeels (Figure 13). Of 2,651 otoliths examined, 36.2% were from 0 group sandeels, with average length of 5 cm long, with none from 1+ group sandeels although one sample contained 1+ bones. In terms of biomass, 0 group and older sandeels contributed 58.6% and 0.1% by mass of the diet, respectively. This sandeel biomass proportion is an increase on 48% found in 2007 but it is still the third lowest on record. Clupeids (mainly sprat *Sprattus sprattus*) contributed 20.5% of the biomass and occurred in 56.5% of regurgitations. In 2005, pipefish were found in only two samples, however, the prevalence of this species increased dramatically in 2006 and 2007 and a similar proportion (39.1%) was found in 2008. In half of the samples, only traces of pipefish were found with just a few vertebrae or scales detected during lab analysis and the species was rarely visible in intact regurgitations. Thus, although pipefish were being taken in significant quantities they were of very little value in terms of biomass. The remains of other items found were Gadidae (in 19 regurgitates, 13 of which contained rockling), mollusc (2) and small crustacea (2). The number of samples containing rockling is similar to 2007 when it first appeared in large quantities in kittiwake diet on the Isle of May but as they were all small pelagic immatures it was not possible to identify them to species.

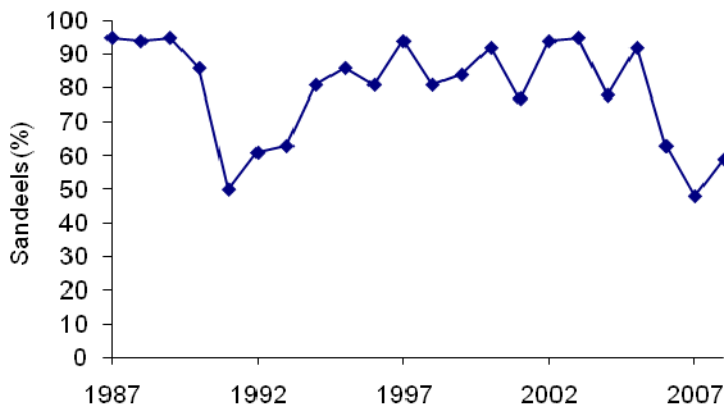


Figure 13. Percentage of sandeels (by weight) in the diet of young black-legged kittiwakes on the Isle of May, 1987-2008

Common guillemot

About 76% of the 825 food items delivered to chicks were clupeids. All those that could be identified to species were sprat. Most were assigned to the medium (11 cm) or small (9 cm) size categories (Table 8). About 20% of the fish were sandeels; this is the first year since 2002 that sandeels have been a major component of the diet of young guillemots (Figure 14). All were 1 group or older. Clupeids made up 93% of the diet by weight, sandeels were the next commonest prey making up 20% of feeds and 6% of the total mass. Identification of Gadidae in the field is extremely difficult but saithe *Pollarchius virens* and whiting *Merlangius merlangus* were specifically identified among the 31 gadoids seen. In 2008, more 'unusual' prey items were recorded than usual including Yarrell's blenny *Chirolophis ascanii* (3), flatfish (2), unidentified rockling (1), small squid (1) and one other species (1) that could not be identified. The average weight of a prey item (estimated from body length and mass:length relationships) was 11.4 g, the highest recorded. One exceptional fish, not included above since it was found in the colony so it was unclear whether it had been for display or just been too large for a chick to swallow, was a haddock *Melanogrammus aeglefinus* 14 cm long and weighing 23.8 g.

The above data are directly comparable with those from earlier years. In addition Kate Ashbrook collected data as part of her studies between 7 June and 9 July. The 831 items were Clupeidae (589), sandeels (169), Gadidae (63), squid (6), Yarrell's blenny (2) and unidentified other species (2).

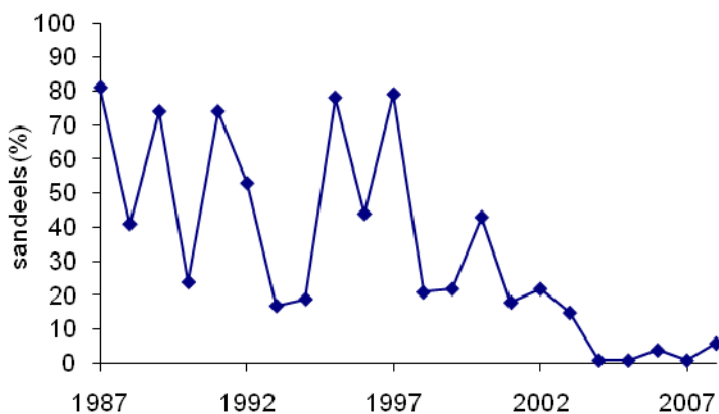


Figure 14. Percentage of sandeels (by weight) in the diet of young common guillemot on the Isle of May, 1987-2008

Razorbill

Sandeels made up the bulk of the fish brought in by razorbills, being the only or main species recorded in 127 (80.4%) of the 158 feeds where the fish were clearly visible (Table 9). In 80 (63%) of the 127 loads containing sandeels the fish were 0 group but the remainder were older fish. The small clupeids present in 8 (6.3%) of loads were unidentifiable but large individuals in 23 (18.1%) of loads appeared to be sprats of the size being taken by puffins. Unusually, juvenile rockling (in 2 loads), and Gadidae (2) were also recorded.

Atlantic puffin

Sandeels made up 64% by number and 72% by biomass in the diet of young Atlantic puffins (Figure 15). Most sandeels were 0 group, between 4 and 7 cm long, with only 4 (0.4%) fish longer than 8 cm being recorded (Table 10). Most of the remainder of the diet was made up of rockling (34% by number but due to their small size only 13% by mass) and clupeids (1.5% by number but 12% by weight due to the very large size). The mean load size of 5.9g was the second lowest recorded (previous lowest was 5.8 g in 2007) for puffins on the Isle of May.

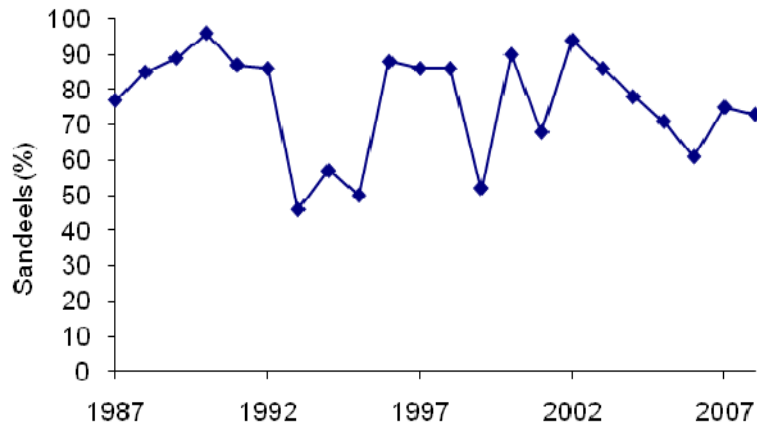


Figure 15. Percentage of sandeels (by weight) in the diet of young Atlantic puffin on the Isle of May, 1987-2008

4 References

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5 Further reading

The following is a list of papers on Isle of May seabirds published or in press since publication of the 2007 report.

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Watanuki, Y, Daunt, F, Takahashi, A, Newell, M, Wanless, S, Sato, K, & Miyazaki N (2008) Microhabitat use and prey capture of a bottom feeding top predator, the European shag, as shown by camera loggers. *Marine Ecology Progress Series*, 356, 283-293.

6 Appendices

Appendix 1: Breeding success

Table 1. Breeding success of northern fulmars on the Isle of May in 2008

<i>Area</i>	<i>Incubating birds</i>	<i>No. probably hatched</i>	<i>Young fledged</i>
Cleaver	8	4	4
Pilgrim's Haven	3	2	1
Cornerstone	2	0	0
Loch (S)	25	2	1
Greengates	53	16	10
Horse Hole	9	2	1
Tarbet	14	5	5
Low Light	3	1	1
Colm's Hole	4	1	1
Rona	0	0	0
Total	121	33	24
Overall mean			0.20 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.

Table 2. Breeding success of European shags on the Isle of May in 2008

	<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	4	0	0	3	1	9	2.25
South Horn	1	0	0	0	1	3	3.00
Pilgrim's Haven	5	0	2	2	1	9	1.80
Mill Door (N)	5	0	1	2	1	8	1.60
Mill Door (S)	6	0	1	1	3	12	2.00
Horse Hole	10	0	1	5	2	17	1.70
North Horn	15	0	3	8	3	28	1.87
Tarbet	9	0	1	2	4	17	1.89
Low Light	5	0	0	4	1	11	2.20
Mean ± se							2.03±0.14
Total	60	0	9	27	17	114	1.90

Notes:

No nests were built in the plots at South Ness, Lady's Bed Stack, Chatterstones, North of Pilgrim's Haven, South Face, Bishop's Cove or Colm's Hole in 2008. Chicks alive on 19 August were assumed to have fledged.

Table 3. Breeding success of black-legged kittiwakes on the Isle of May in 2008

Area	Completed nests	Trace nests	Other pairs with site	Fledged young per completed nest				Total young produced	Fledging success per completed nest
				0	1	2	3		
Cleaver	22	2	5	22	0	0	0	0	0.00
South Horn	50	2	11	38	11	1	0	13	0.26
Pilgrim's Haven	8	10	5	8	0	0	0	0	0.00
South Face	15	1	5	10	5	0	0	5	0.33
Colony 4	39	2	4	28	11	0	0	11	0.28
Hide Face	27	3	9	16	11	0	0	11	0.41
Cornerstone	65	6	10	42	22	1	0	24	0.37
Lock (S)	0	1	0	0	0	0	0	0	0.00
Loch (N)	43	6	12	43	0	0	0	0	0.00
Greengates	44	3	1	28	16	0	0	16	0.36
Bishop's Cove	26	4	10	26	0	0	0	0	0.00
Horse Hole	7	3	0	7	0	0	0	0	0.00
Horse Hole	40	2	2	34	6	0	0	6	0.15
Iron Bridge	40	1	2	21	18	1	0	20	0.50
Rona	39	8	10	37	2	0	0	2	0.05
Tarbet	7	3	0	5	2	0	0	2	0.29
Low Light	13	1	2	13	0	0	0	0	0.00
Colm's Hole	22	2	5	22	0	0	0	0	0.00
Mean ± se									0.18± 0.04
Total	485	58	88	378	104	6	0	110	0.23

Table 4. Breeding success of auks on the Isle of May in 2008

Species	Area	Pairs laying	Young hatched	Young "fledged"	Young leaving / pair
Guillemot	Dense	254	209	173	0.68
	Hide / White Ledge	83	66	46	0.55
	Colony 4	218	165	130	0.60
	South	36	28	18	0.50
	Cornerstone	216	182	137	0.63
	Mean ± se				
	Total	807	650	504	0.63
Razorbill	Hide / White Ledge	27	22	20	0.74
	Colony 4	54	39	28	0.52
	South	19	14	10	0.53
	Cornerstone	70	59	41	0.59
	Mean ± se				
	Total	170	134	99	0.58
Puffin	Lady's Bed	45		20	0.44
	Kirkhaven	42		26	0.62
	Burrian	45		13	0.29
	Rona	47		27	0.57
	Mean ± se				
	Total	179		86	0.48

Table 5. Breeding success (mean number of young reared per breeding pair) of seabirds on the Isle of May, 1995-2008

<i>Species</i>	<i>1995</i>	<i>1996</i>	<i>1997</i>	<i>1998</i>	<i>1999</i>	<i>2000</i>	<i>2001</i>
Northern fulmar	0.48 (126)	0.44 (135)	0.37 (136)	0.35 (120)	0.47 (115)	0.37 (143)	0.26 (134)
European shag	0.84 (131)	1.05 (105)	0.92 (109)	0.85 (125)	0.33 (58)	1.48 (127)	1.53 (135)
Black-legged kittiwake	0.40 (874)	0.56 (825)	0.40 (822)	0.02 (683)	0.20 (616)	0.97 (545)	0.61 (459)
Common guillemot	0.81 (805)	0.82 (786)	0.77 (842)	0.73 (852)	0.66 (870)	0.73 (942)	0.63 (975)
Razorbill	0.62 (143)	0.63 (140)	0.71 (132)	0.57 (134)	0.52 (142)	0.68 (149)	0.60 (167)
Atlantic puffin	0.84 (180)	0.78 (173)	0.65 (166)	0.54 (179)	0.58 (181)	0.73 (132)	0.78 (185)
	<i>2002</i>	<i>2003</i>	<i>2004</i>	<i>2005</i>	<i>2006</i>	<i>2007</i>	<i>2008</i>
Northern fulmar	0.48 (131)	0.44 (109)	0.21 (97)	0.27 (135)	0.44 (139)	0.21 (141)	0.20 (121)
European shag	1.66 (130)	1.83 (156)	0.25 (103)	0.48 (42)	1.22 (81)	1.07 (57)	1.90 (60)
Black-legged kittiwake	0.47 (477)	0.77 (423)	0.29 (476)	0.85 (675)	0.47 (613)	0.24 (609)	0.23 (485)
Common guillemot	0.68 (955)	0.68 (1014)	0.50 (984)	0.63 (945)	0.41 (932)	0.28 (850)	0.63 (807)
Razorbill	0.65 (167)	0.59 (177)	0.54 (190)	0.55 (200)	0.62 (190)	0.63 (188)	0.58 (170)
Atlantic puffin	0.72 (174)	0.77 (195)	0.60 (196)	0.71 (184)	0.68 (166)	0.29 (158)	0.48 (179)

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.

The figures for puffin in recent years allow for losses after the final check.

Appendix 2: Annual return rates

Table 6. Annual return rates of adult seabirds on the Isle of May, 1992-2008

<i>Species</i>	<i>No. seen in 2007</i>	<i>No. seen in 2008</i>	<i>Return rate (%)</i>						
			<i>2007-08</i>	<i>2006-07</i>	<i>2005-06</i>	<i>2004-05</i>	<i>2003-04</i>	<i>2002-03</i>	<i>2001-02</i>
Kittiwake	107	71	66.4	62.9	80.9	69.7	81.8	84.2	73.5
Guillemot	236	177	75.0	75.2	86.9	83.9	90.1	87.0	87.0
Razorbill	36	25	69.4	80.0	88.2	84.6	84.3	77.8	83.8
Puffin	148	87	59.4	56.9	81.8	77.0	87.9	85.2	83.5
Shag	143	101	70.6	60.8	83.3	36.4	82.2	92.7	92.2
	<i>2000-01</i>	<i>1999-00</i>	<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>
Kittiwake	81.2	72.9	73.1	66.2	78.7	75.8	72.7	79.5	80.8
Guillemot	89.6	91.6	90.2	94.6	91.8	88.9	95.6	95.0	95.0
Razorbill	82.9	66.7	86.9	65.5	82.1	56.6	92.6	84.5	91.5
Puffin	90.5	82.8	88.2	85.5	90.7	90.1	93.0	93.1	84.0
Shag	89.8	89.4	65.8	93.6	91.1	93.6	88.5	13.4	79.6

Notes:

Only birds which had definitely bred in 2007 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 2008

	<i>Black-legged kittiwake</i>	<i>European shag</i>
No. of regurgitations	46	36
Range of dates	11 June-16 July	20 June-14 July
Total weight (g)	714	974
% regurgitations with sandeels	76.1	61.1
with Gadidae	41.3	44.4
with Clupeidae	56.5	16.7
with flatfish	0	0.1
with butterfish	0	25.0
with Cottidae	0	11.1
with pipefish	39.1	0
% (by weight) of sandeels in sample	58.7	48.4
	36.2	49.2
% (by number) of sandeels in sample		
Lengths of most sandeels (cm)	5	9
Other remains identified	Small crustacea (1 sample), mollusc (2).	Gobiidae (12), crustacea (6), mollusc (3), Dragonet (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 2008

	<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)		9	12	16	11	13	15		6	8	9
All-day watches											
19 June	0	22	36	0	27	115	2	0	7	3	0
21 June	0	2	2	0	13	12	0	0	2	1	0
28 June	0	2	2	0	1	42	3	0	0	1	0
Other records											
3 June - 17 July	0	62	37	1	60	338	7	0	11	6	0
Total	0	88	77	1	101	507	12	0	20	11	0

Notes:

In addition, there were Yarrell's blenny *Chirolophis ascanii* (3), flatfish (2), rockling sp. (1), small squid (1) and other unknown species (1).

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

Table 9. Food of young razorbills on the Isle of May in 2008

	<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									
19 June	12	6	12	2	0	2	2	5	0
21 June	11	3	4	0	0	0	0	0	0
28 June	14	2	1	1	6	1	1	1	0
Other records									
15 June – 6									
July	43	11	8	0	0	2	2	5	1
Total	80	22	25	3	6	5	5	11	1

Notes:

There were also 2 loads of rockling, and one with a single Gadidae.

All the small sandeels appeared to be 0 group.

1 load of small sandeels also had a single Gadidae.

1 load of small sandeels also had 2 medium sandeels.

1 load of a large sandeel also had a single small sandeel.

2 loads of a large sandeel also had 1 medium sandeel.

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

Table 10. Food of young Atlantic puffins on the Isle of May, 3 June to 18 July 2008

	<i>Sample size</i>	<i>Mean</i>	<i>s.e</i>
a) Load weight (g)	106	5.93	0.3
b) Fish/load	107	15.1	0.7
c) Numbers and lengths of fish (mm)			
Sandeels <i>Ammodytes sp.</i>	1025	53.1	0.27
Unidentified Clupeid (<i>Clupeidae</i>)	18	40.1	0.7
Sprat <i>Sprattus sprattus</i>	6	121.6	8.4
Saithe <i>Pollachius virens</i>	3	38.0	4.9
Rockling <i>sp.</i> (Gadidae)	548	32.0	0.18
Whiting (<i>Merlangius merlangus</i>)	4	44.8	5.8
Unidentified Gadidae	8	49.6	3.66

Note: To judge from at-sea surveys nearby most of the Clupeidae category were probably small herring (*S. Greenstreet*).

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, 1986-2008

<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
2007	36.6	49.9
2008	46.7	72.4

Notes:

Figures are based on 87-269 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 2008 observations were made on 106-138 broods between 10 and 20 July.

Table 12. Percentage of sandeels (by weight) in the diet of young seabirds on the Isle of May, 1989-2008

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

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Shag	98	<50	87	95	98	96	49	41	53	28	48
Kittiwake	81	84	92	76	94	91	79	92	63	48	59
Guillemot	21	22	43	18	22	15	2	1	4	1	6
Puffin	86	52	90	68	94	86	78	71	61	75	72

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, 1986-2008

<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
2007	19 May	1.80
2008	15 May	1.75